REGULATION AND INNOVATION:

THE CASE OF METERING IN PUBLIC UTILITIES

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Declaration

The material contained in this thesis is my own work, has not been published elsewhere, and is an original composition.

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ABSTRACT

During the past twenty years there have been sharply contrasting policies towards the regulation of public utilities in France and the United Kingdom. In the UK there has been a policy of deregulation where private ownership abounds, encouraging market forces vis-à-vis political forces. In France by contrast a policy of 'public service' is still paramount with many of the utilities remaining in government hands and enjoying monopoly rights. This research explores a third dynamic in the regulation of utilities, that of technological innovation. In particular this thesis examines the development of metering technology in relation to the regulation of four utility sectors; electricity; gas; water and telecommunications in France and the UK. Using a case study methodology it examines five theoretical approaches that can be used to analyse the role of innovation in regulatory change. These are the *Techno-Economic Paradigm*; *Systems Theory*; *Sociotechnical Constituencies*; *Techno-Economic Networks* and *Evolutionary Theory*. The analysis is then used to illuminate and guide future policy making towards public utility regulation and innovation.

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DEFINITIONS

Regulation:

Regulation is the term used to describe homeostatic systems that are determined by a set of rules. The regulation of blood sugar level in the human body will be taken as an example to illustrate this. When carbohydrate foods containing sugar and starches are digested, they are absorbed into the bloodstream as glucose. Insulin, a hormone produced by the pancreas, is released into the bloodstream when the level of glucose rises, and the hormone enables glucose to be stored in the fat tissues. Similarly when the glucose level in the bloodstream drops, less insulin is produced, and sugars which are laid down in the fat tissues are used up (Vander *et al.* 1994: pp.602-623). This definition becomes clearer when the word 'regulation' is translated into French. The translation provides two words each with different meanings (Mansion, 1945 and Aglietta, 1979: p.316). *Régulation* means a 'balancing mechanism' or 'equilibrium' and *réglementation* means 'the implementation of rules'. Thus this thesis considers that regulation is a two-part process. First there is a system of balancing that is required for a stable world (*régulation*). Second a set of social and/or scientific rules that are implemented to maintain this balance (*réglementation*). Just as in the human body has many systems of regulation (e.g. the concentration of blood sugar, salts, etc.); there are many systems of regulation within social systems. Such factors as the laws of supply and demand, the need for social equality, asymmetries in knowledge and environmental impacts are important and often conflicting regulatory systems. A regulator is one who (e.g. an individual or organisation), or that which (e.g. a controlling device for the speed of a machine or the laws of supply and demand in a market economy) governs a system of regulation. This thesis examines the role that innovation has on the regulatory systems acting on public utilities.

Deregulation:

Deregulation is the term used to describe the process of converting vertically integrated public utilities, which were previously owned and operated by the State, into their 'naturally monopolistic' and competitive components (Beesley 1992). In other words it is the process of changing the *régime of regulation* (the social and economic environment) that is governed by political devices to one that is governed by market mechanisms. Moreover in some cases the deregulatory process has been coupled with privatisation where the production, transportation and supply functions have been transferred from the public to the private sector. The term deregulation is considered to be somewhat of a misnomer in that the process of creating markets inevitably involves the creation of regulatory institutions in order to maintain a competitive environment.

Public Utility:

Public utilities are industries that are subject to economies of scale resulting in their 'natural monopoly' position. For example there are cost savings in having only one water main in the street, and similarly this is the case with other large infrastructure industries such as electricity, telecommunications and gas. There is also a body of legal and historical precedent to support the view that an industry must be of some public or social significance to be considered a public utility. The strategic and political importance of the gas, electricity, telephone and water industries have always been present in the management of utilities. Moreover, the concept of universal access at equal cost has been a particular theme in the supply of utilities as a social right, rather than chosen luxury, over the past fifty years.

Innovation:

Innovation is considered to be the act of making novel changes (technical or procedural) that enhance the wellbeing and efficiency of an organisation and society.

Meter:

A meter is a device for measuring the consumption and/or demand of a product. Meters become increasing important in public utility networks that require to be built to cater for the peak demand. It follows that during times of slack demand the system is running inefficiently. Metering allows differential pricing, where the price is more expensive during peak times and cheaper during off-peak times. It is the development of this technology that is studied in this thesis.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Since the social and economic reconstruction that was required after Word War II, it has been argued that the electricity, gas, water and telecommunications industries should be managed on mixed 'neo-classical' principles (Helm, 1995). In these terms a high degree of public operation and ownership (or strict private regulation) was widely accepted by a variety of Governments and academics world-wide (Lee, 1969; Turvey & Anderson, 1977; Littlechild, 1979 and Helm, 1995). Today, there is a fundamental shift in the principles of public utility regulation. Now it is suggested by many that an increased role for market forces is desirable where private sector ownership is seen as the most efficient mechanism to achieve economic optimality. Meanwhile such factors as social equality and the environment are thought to be more effectively dealt with by making companies legally liable for these provisions (Littlechild, 1986 and Beesley, 1992). Thus, competition is now recognised as a key dynamic in the process of discovery and co-ordination that is important for an efficient operation of a network infrastructure. Consequently vertically integrated public utilities, which were previously owned and operated by the State, have in some cases been broken up into their 'naturally monopolistic' and competitive components. Moreover in some cases the production, transportation and supply functions have been transferred from the public to the private sector (Harper, 1989; Henney, 1994; O'Neill, 1996 and Surrey, 1996). The role that technological innovation has played in this revolution is unclear and it is this dynamic which is investigated in this thesis.

Over the past twenty years there have been, concurrent with the deregulation process, new developments in data processing and telecommunications which have allowed the introduction of such technology as 'solid state' (or electronic) metering and communications systems which can transfer data at the speed of light. This has meant that information about pricing, product quality and load management can be manipulated on a 'real-time' basis and this has arguably facilitated the introduction of deregulation (Soishansi, 1991). The United Kingdom (UK) has been in the vanguard of this change process. During the nineteen-eighties and nineties the UK's telecommunications, gas, electricity and water suppliers have been floated on the Stock Exchange and competition has been introduced into electricity generation, electricity supply, gas supply and long distance telecommunications supply (Harper, 1989; Henney, 1994; O'Neill 1996 and Surrey, 1996).

One would have thought that France, as a major trading nation, would inherently be in favour of free trade and throw itself into the oncoming tide of market liberalisation as was occurring in the UK and elsewhere. Yet Woods (1996) suggests that the country has a basic distrust of unbridled capitalism, which it regards as being essentially Anglo-Saxon in its nature. Neither does he suggest that the French share, to anything like the same extent, the UK's fear of becoming uncompetitive due to high personnel costs and a somewhat rigid labour market. Also Woods (1996) adds that, despite its acclaimed *élan*, social order is in fact a quality that is much admired in France. As Charles de Gaulle once comically put it "how can one govern a country that has two hundred cheeses?" As a result the public owned and operated utility monopolies have remained intact until recently. The French position however has increasingly come under threat not least from the European Union where many of its laws run contrary, at least in spirit, to the single European market. As the market liberalisation policy of the European Commission is implemented across the Continent, the French Government has started to pass (rather grudgingly) reforms designed to curb potentially anti-competitive practices in its utilities (Cameron, 1995 and Woods, 1996). The liberalisation of the telecommunications sector in 1998 can be cited as an example of this. The French position is summarised by Bouttes & Leban (1995). They consider that the utilities' role of 'public service' should not be compromised by the introduction of competition. So although it may be technically feasible to unbundle (split up) the production activity from the transport and supply functions to allow the trading of services across the infrastructure, this may not be in the best interests of France. Bouttes & Leban (1995) suggest that the role that technology plays in maintaining this position is great, in that it is regarded to be of key importance in deciding the form of regulation best suited to each industry and each country. Thus the analysis of regulation depends on the precise identification of a combination of the sector's economic, social, geopolitical and technical specifications. One purpose of this thesis is to examine what the specifications may be.

1.2 AIM

The aim of the thesis is to evaluate and develop theoretical frameworks that can explain and evaluate regulatory and technical change in public utilities. This approach differs from many studies of utility industries in that it is concerned with the management of change in well-established infrastructure networks rather than with the creation of new networks (Hughes, 1983). In this way it builds from the approach of Thomas Hughes and works within the spirit of his study of the development of the electricity infrastructure in *Networks of Power* (Hughes, 1983). In fact this study can be seen as looking at the next phase in network systems, in particular studying the change taking place in a network once it has become firmly established.

The approach is also significantly different from ones adopted in many textbooks on the management of change within firms. Change in these contexts is seen as a matter of how firms react to external factors either in the competitive (Pettigrew & Whipp, 1991), social or technological environment (Woodward, 1965 and Zuboff, 1988). In this study change is viewed in terms of the differing factors that determine the *régimes of regulation* which work out-with the firm. Thus it is an inter-sectoral study rather than an inter-firm or intra-firm study.

It also differs from many mainstream commentators on regulation, who see socio-political factors (Aglietta, 1979; Reagan, 1987; Boyer, 1988a and Boyer, 1988b), and market discipline (Littlechild, 1986 and Beesley, 1992) as the prime factors in regulation. Instead, it explores in detail by means of empirical evidence presented in eight case studies, the mutual shaping of information technology (more precisely metering technology) and regulation in UK and French utilities over the past twenty years.

1.3 OUTLINE OF THE THESIS

The thesis consists of three parts: Part I presents a literature review and outlines the research method; Part II discusses the eight case studies; and Part III consolidates the literature and case studies in presenting an analysis and conclusions.

The research design is presented in chapter 2. The methodology adopted is an 'emergent grounded' approach where the research is founded on multiple case studies that take a logical progression from exploration and descriptive phases in Parts I and II (the literature review and case studies), to an explanatory phase in Part III (the analysis). The understanding of the role that theory plays in this thesis is crucial. A 'theory' is argued to be a method of explaining phenomena, in this case the interrelation of technology and regulation. Thus theory is argued to be more than a metaphor in that it is a useful heuristic device. So theory is used as a framework for conceptualising the phenomena that are being studied. This means that the theoretical frameworks that are explored may have significant differences (logical, empirical, rhetorical and metaphysical) and that may be helpful in the illumination of the different aspects of the management of the technology/regulatory interface in public utilities.

The literature review covers three distinct fields: regulation; public utility management; and technological innovation. Regulation can be regarded as a negative feedback system in which asymmetries, whether due to social, economic or technological factors are balanced by rules which may (or may not) be codified in legal statutes. Chapter 3 presents three approaches to regulation: market theories of regulation; a political scientist's formulation of regulation; and a technology and innovation perspective to regulation. It is this latter approach and in particular the *Techno-Economic Paradigm* which is explored in further detail later in the thesis. This chapter also gives an account of various regulatory institutions. Chapter 4 then presents the role of metering technology in public utility management. This chapter argues that public utility regulation needs to call on not only economic but also social and technical knowledge. It also addresses the specific role of metering in the industries being studied, namely the electricity, gas, water and telecommunications industries. The chapter concludes with an outline of the *Principal-Agent* model of regulation and a discussion of the different methods of regulation found in public utilities today. As a technological perspective on regulation is being considered, a review of the literature on technological innovation is presented in chapter 5. In this chapter technology is initially viewed through its many different perspectives. It then explains and justifies the methods of analysing technical change used in evaluating the interaction of metering and regulation that are presented later in the thesis. These theoretical frameworks are *Systems Theory*, *Sociotechnical Constituencies*, *Techno-Economic Networks* and *Evolutionary Theory*.

Part II then presents the eight case studies with a chapter assigned to each case study. This exploratory stage of the thesis consists of: chapter 6, electricity in the UK; chapter 7, electricity in France; chapter 8, gas in the UK; chapter 9, gas in France; chapter 10 water in the UK; chapter 11 water in France; chapter 12 telecommunications in the UK; and chapter 13 telecommunications in France. Each case study takes a similar format: there is a brief introduction; there is then a description of the network infrastructure;

this is followed by an exploration of the role of metering technology; and finally a summary of the findings is presented. The only exception to this format can be found in the case studies concerning telecommunications, in chapters 12 and 13. In these telecommunications chapters, the metering of telephony and telecommunications in energy (electricity and gas) and water metering, are dealt with in separate sections.

Part III consists of the descriptive and explanatory phases of this thesis. The analysis consists of four chapters. Chapter 14 examines the role that information technology has played in the changes that have occurred in the regulation of public utilities over the past twenty years. Here, the applicability of the *Techno-Economic Paradigm* for explaining this change is evaluated. The role that regulation plays in the shaping of metering technology is then considered in chapter 15. This provides a more detailed analysis of the texture of innovation than is presented in chapter 14 since it addresses specifically the factors shaping metering technology. The theoretical frameworks discussed here are *Systems Theory, Sociotechnical Constituencies* and *Evolutionary Theory*. Also within the same *Systems Theory* framework, chapter 16 then considers how regulation has been shaped by socio-technical factors. In this analysis, *Evolutionary Theory* again is applied as an explanatory tool together with *Techno-Economic Networks*. Chapters 15 and 16 both conclude with a discussion and recommendations on technology and regulatory policy respectively. The findings of the thesis and the implications for public utility management in the future are presented in the conclusions in chapter 17. In the conclusions, there is a discussion of the validity of the theoretical frameworks used in the thesis and recommendations are made for further research.

PART I

THE METHODOLOGY AND LITERATURE REVIEW

CHAPTER 2

METHODOLOGY

2.1 INTRODUCTION

Before embarking on a study of this sort one must not only consider the research design but also the personal motivation behind the project. This enables one both to reflect the inbuilt biases in the project, the theoretical approach that one wishes to adopt and also inform the reader of the academic and commercial background of the author. Thus the methodology departs from *grounded theory* described by Glaser & Strauss (1967) in that this thesis uses theoretical descriptive frameworks to analyse qualitative data (Yin, 1994). In saying this the methodology takes an exploratory approach in the case studies (chapters 6 to 13) and an explanatory approach in the analysis (chapters 14 to 16). This in many ways may appear similar to an inductive *grounded theory* approach. Yet the study commences with clear theoretical propositions (chapters 3 to 5), moves into an exploratory phase (chapters 6 to 13) which is relevant to the hypothesis-generating approach developed by Glaser and Strauss (1967), and finishes with an explanatory phase related to the hypothesis-testing approach described by Yin (1994). This is described as an 'emergent grounded' approach by Saunders *et al.* (1997: p.350) and is the methodology used in this study.

The first section of this chapter considers the author's (my own) background and motivations for the project. This is written unlike the rest of the thesis in the first person and is formatted as a personal biography. The second section then discuss the research design (Yin, 1994: p.20). This is essentially the blueprint for the research, which takes a case study format. The method of conducting the case study and collecting the evidence is described in the third section. This involves a description of the sources of evidence, the generation of primary and secondary research data, and the creation of a study programme. The chapter concludes with a description of the analytical procedures used in the thesis.

2.2 PROJECT MOTIVATION

In October 1995 I began work on this PhD, studying the interrelation between the deregulation of public utilities and the development of information and communication technologies. Prior to this I had gained a BSc in geology at Aberdeen University and went on to work in the oil and minerals industry. During my time working as an *exploration geologist*, with amongst other companies, British Petroleum, it became clear that various social scientific skills (in my case business skills) as well as scientific skills, were required to be a successful geologist. So in order to develop this area I took an MBA at Edinburgh University in 1987. I then joined British Gas and embarked on a career in general management. At this time British industry was undergoing a sea change in philosophy on how businesses should be run. British Gas had been privatised in 1986 and competition was beginning to develop. This first-hand experience of deregulation kindled the embers of the fire that was eventually realised in my PhD studies. In 1989, in order to widen my experience of public utility management, I joined Scottish Hydro-Electric and this was where my knowledge of the UK electricity industry is founded. In my role as *Marketing Systems Manager* I participated in the transfer of the publicly owned North of Scotland Hydro-Electric Board to the privately listed Scottish Hydro-Electric plc in 1991. Also I was responsible for the development of the company's new information and communications systems which were needed for operation in the deregulated environment. In particular, I was involved in the management of the development of remote metering systems. It was during this period that the framework of my PhD thesis began to take shape. I felt that the deregulation that I was participating in had a close relationship with innovations occurring in information, communications and metering technologies. By 1994 I was ready to pursue this question further, both in the academic and commercial sphere. To this end I joined Ian Pope Associates (IPA) as an Associate Consultant, and at the same time revived contacts with my academic mentors at Edinburgh University. IPA is an independent consultancy established in 1989 and its business covers a wide range of strategic and commercial issues including regulatory issues in the energy utilities. IPA's clients include Governments, international lending agencies and regulatory bodies as well as commercial companies. By June 1995, my mentors at both IPA and Edinburgh University had succeeded in gaining an *Industrial Collaborative Studentship* between the Economic and Social Research Council (ESRC) and IPA. The fruits of that studentship are presented in this thesis.

From this brief biography some notable features stand out. The project is primarily self motivated, and is grounded in questions that arose at first hand, from my experience while working in both operational and management roles in public utilities. For better or worse (I would sincerely hope for the better) my thesis is influenced from this experience and the knowledge which has been gained from my past work. This is considered to be an integral part of the project methodology. From the academic point of view, my foundations are in science (geology) and applied social science (MBA) which form a robust empirical and logical epistemological background to my research. This has been further supported by courses undertaken at The Graduate School for Social Sciences at The University of Edinburgh. These courses provided a valuable insight into research design and technology studies, as well as qualitative and quantitative methods of data generation and analysis. Moreover, this training provided a basis for a phenomenological approach to the research, which (as will be discussed in the next section) is manifest by a case study rather than an experimental research design. In saying this many remnants of my positivistic background remain. The fundamental hypotheses: 'does technology have an influence on regulation?'; and vice versa 'does regulation effect technology?' have empirical flavours to them. Yet, I consider that regulation and technology are phenomena, which cannot only be studied by logical and empirical epistemology alone. Moreover, I consider a phenomenon to be anything that can be observed by our senses and it is my firm belief that my senses are grounded in both social and non-social processes. The real interest for me is studying phenomenologically the interaction of these two components: the social and the scientific. My epistemological position will be justified further, not only in this chapter, but also throughout the thesis as is consistent with an 'emergent grounded' methodology. Evidence of my scientific background also comes in my form of prose which, apart from this section, is written in the third person. This is not for any philosophical reason but merely that the third person is the form that I have written all my previous work, both in the academic and commercial world, and it is the one in which I feel most expressive and comfortable.

2.3 THE RESEARCH DESIGN

2.3.1 The Project Aims

The project has two distinct aims: to describe the interaction of technological and regulatory development; and to provide a theoretical basis on which technology and regulatory policy can be constructed. There have been a number of important developments in various countries in recent years in the way public utilities (electricity, gas, water and telecommunications) are organised. These constitutional changes have involved three major activities. Firstly, the ownership of utilities has shifted from Government to the private sector. Secondly, monolithic monopolies have been broken up both horizontally and vertically to varying extents. Thirdly, competition, at least in principle, has been introduced to encourage efficiency and stimulate new technology while maintaining a satisfactory quality of service (Harper, 1989; Henney, 1994; O'Neill, 1996 and Surrey, 1996). The purpose of this piece of post graduate research is to study how technology has been affected by these changes and to examine what influence technology has had in stimulating this move towards deregulation.

In considering a research methodology two designs come to mind, the quasi-experiment and the case study. The research could at first sight be seen to be somewhat quasi-experimental (Cook & Campbell, 1979). For example, over the past twenty years utilities in the UK have been privatised, increasing the role of market forces. Indeed titles such as Surrey's *The British Electricity Experiment. Privatization: the Record, the Issues, the Lessons* (1996) would suggest that such a methodology would be valid. This is not the case. A quasi-experiment is effectively meant to mimic the scientific experimental method and as explained in section 2.3.3 this thesis is dealing with phenomena. The results from this study can neither be logically deduced as in a mathematical proof or falsified as in a scientific experiment. In addition, the conducting of an experiment needs very tight constraints on *comparison* and *control* and such factors as *external* and *internal validity* cannot be fully achieved in this study. Yin (1994) explains that the case study is most useful when it investigates a contemporary phenomenon within its real life context especially when the boundaries of the phenomenon are not clearly evident. In addition, the case study enquiry copes with the technically distinct situation in which there will be many more variables of interest than data points and more than one result. The data presented for analysis rely on multiple sources of evidence and analysis benefits from prior data collection and analysis. Cook & Campbell (1979: p.96) also explain that the case study is not just a subset of a quasi-experimental design but also a methodology in its own right:

"Certainly the case study as normally practised should not be demeaned by identification with the one-group post-test design."

Thus the methodology of this research falls clearly within the realms of the case study approach.

2.3.2 The Units of Analysis

As with any fundamental idea on which research designs are made, this research is based on a comparison of a number of units of analysis (Hakim, 1987). Section 3.4 describes a theory, the *Techno-Economic Paradigm*, that suggests that technology has a direct effect on *régimes of regulation* (Perez, 1983; Freeman & Perez, 1988; and Freeman & Soete, 1993). In addition there are also suggestions that the *régime of regulation* can have a direct bearing on the speed and trajectory of technological development (Offer, 1995). Nevertheless there is continuing debate on the precise nature of these effects. In order to study these effects it is important to examine contrasts between regulatory environments that are as extreme as possible, subject to practical constraints. The greatest contrasts may be expected between a command economy of say China, or a developing economy such as India, and compare that to the supposedly developed market economy of the UK. However the logistical problems that would be involved in accessing data and conducting research in command and developing economies preclude their consideration. Accordingly, to provide ease of access to information the project is comparing two Western economies who have pursued contrasting policies in utility regulation, namely the UK and France. The concept of a free market, which is displayed in utility deregulation, has been a significant feature of UK Government policy over the past twenty years. This is contrasted with an economy based on mixed 'neo-classical' principles which has been pursued by the various administrations in France.

The research broadly works within a *Systems Theory* framework (Hughes, 1983) but it can also be split into two levels of scale. On a *macro* scale it considers how regulation (usually maintained by legal statutes) and technology interact. On a *meso* level the interactions between public utilities (gas, electricity, water and telecommunications) and metering technology, are studied. More precisely the *Sociotechnical Constituencies* approach as described by Molina (1996) is used to construct a technical dimension in network infrastructure development. In addition, *Techno-Economic Networks* (Callon,

1992) are used to study the shaping and remoulding of actors (including technology) in the creation of new regulatory régimes. Also *Evolutionary Theory* (see Cziko, 1995: ch.10) is used both in a *meso* and *macro* scale to map technological and regulatory infrastructure changes (see sections 5.3, 15.3 and 16.3 for further details of these approaches).

Another method of *control* is achieved by comparing as many industries and technologies as practicable. The research has been chosen to cover all utilities that use metering technology, namely, energy (electricity and gas), water and telecommunications. This allows the physical, technological and social constraints of each industry to be taken into account when considering the shaping of the infrastructure terrain.

Another important unit used to bound the case study is that of time. This case study enquiry copes with the period of study running from the twenty years of 1978 to 1998. The object of choosing this period is to capture the change that has occurred in these infrastructure technologies during this time. In saying this, an account is also given in each of the case studies from the period of the industry's creation up to 1978 to provide a historical context.

To summarise, the research is an interactive study of three dimensions, namely regulation, technology and an industrial sector (public utilities). Specifically these dimensions are being represented by a set of variables. Governance is being represented by the contrasting regulatory régimes operating in France and the United Kingdom over the past twenty years. The technology dimension is being represented by regulatory implications of innovations in metering and associated electronic data interchange (EDI) over this time period. The industrial dimension is represented by the specific regulations pertaining to the electricity, gas, water and telecommunications industries. Table 1 shows how the thesis consists of eight comparative case studies in total (4 utilities x 2 countries).

Table 1: The Cases Studies: The Development of Metering Technology in Electricity, Gas, Water and Telecommunications Utilities

	Electricity	**Gas**	**Water**	**Telecoms**
UK	Case Study 1 (Chapter 6)	Case Study 3 (Chapter 8)	Case Study 5 (Chapter 10)	Case Study 7 (Chapter 12)
France	Case Study 2 (Chapter 7)	Case Study 4 (Chapter 9)	Case Study 6 (Chapter 11)	Case Study 8 (Chapter 13)

Although the quasi-experimental form of methodology has been rejected in this study, the rigours of the scientific method are still useful. One of the points of weakness, in the case study format, is the inability to obtain validity by *comparison* and *control*. In an attempt to achieve as much *construct validity* as possible the methodological framework has been tightly defined. Yet within that tight framework as much variation as possible is sought. This is achieved by the selection of distinct phenomena (utilities, regulation and metering), taking as extreme regulatory régimes as practicable (France and the UK) and taking as wide a number of utilities as possible (gas, electricity, water and telecoms). This ensures *internal validity*, at least to some extent, is maintained within the case study format. This attempt to maintain *internal validity* is also made in the data generation procedures described in section 2.4. *External validity* is a little more difficult to achieve. Throughout the thesis comparisons are made with other industries and other innovations and in turn it is hoped that this will reveal new and innovative thoughts about the regulatory and technological process which can be applied to other fields.

2.3.3 The Epistemological Position

Another area where representativeness may be compromised is in the use of theory. In much of the literature, such as in *ethnography* and *grounded theory*, the role of theory development prior to the conduct of case studies is criticised (Glaser & Strauss, 1967). Typically, these positions deliberately avoid specifying any theoretical propositions at the outset of any inquiry. Yin (1994) suggests that this can be misleading and suggests that before conducting research there needs to be an "understanding or theory of what is being studied." This also gives a clue as to the status of theory in phenomenological research, that is, it is a way (which can be just one of many ways) of conceptualising an issue. For this reason the word 'theory' is often replaced by 'programme' in this form of research, as in the *Empirical Programme of Relativism* (EPOR; Collins, 1981) and the *Social Construction of Technology* (The SCOT Programme; Pinch & Bijker, 1990). Thus 'theories', in this piece of work, are considered to be useful instrumental frameworks that can provide a common language to describe phenomena. These 'theories' are then verified and refined in an iterative process of rigorous empirical testing. This thesis is not studying one specific 'theory' in depth rather is comparing a number of 'theoretical frameworks' and studying their philosophical foundations to illustrate their continuities and differences. Appropriate 'theoretical frameworks' are then applied to empirical case studies to provide descriptive insights into the role of technological innovation in regulatory development in the differing sectors of public utility management. The qualified 'theoretical frameworks' are then further used in a prescriptive form as a tool to aid the development of regulation and technology policy.

2.4 DATA GENERATION

2.4.1 The Documentation and Archival Records

Before conducting any primary research it is important to exhaust all the secondary material pertaining to the topic. It would be counter productive, for example, to carry out a survey only to find at some later date that the information sought in the survey is already published. Besides overcoming this, one has also to fully familiarise oneself with the subject so that the primary research is done in the most efficient manner. The first year of this three year project was spent doing this. This involved completion of training courses as well as conducting a substantive literary review.

There are four main sources from which data can be generated in the study of regulation. These are: the legal statutes which define the regulatory mechanisms; the regulatory commission who monitor procedures to enforce quality; the public utility; and the consumers of utility products. The foundation of this research is built on a comprehensive review of these secondary data sources.

The procedural frameworks are set out in Acts of Parliament. In France, some of the key Acts for this study are: The Act of April 1946 which nationalised both gas and electricity industries; a resolution adopted in June 1993 to liberalise the provision of voice telephony services by the beginning of 1998; the French Government's decision that France Télécom (the State telecommunications supplier) should be gradually privatised in September 1993; and the Water acts of 1898, 1935, 1964 and 1992. In the UK the many key sources include: the Electricity Acts of 1947, 1957 and 1989; the Gas Acts of 1948, 1972, 1986, and 1995; the Gas Enterprise Act 1982; the Post Office Acts of 1961 and 1969, the British Telecommunications Act 1981; the Water Acts of 1945, 1973, 1983 and 1989; and the Competition and Service (Utilities) Act 1992. Both countries are also governed by legislation at European level. Some of the most interesting sources come from the European Commission's plans for a liberalisation of European telecommunications and energy markets as well as environmental legislation relevant to the electricity and water industries. These industries are in practice usually the responsibility of the respective Ministries of Industry, Environment and Finance in the UK and France. However, in some instances the day to day management is delegated to a quasi-autonomous regulator or consumers' committee. For example in the UK, The Directors General of telecommunications, of water services, of gas supply, and of electricity supply are statutory appointments. The Acts of Parliament define the Directors' General broad powers and duties, including those of enforcing licence conditions, modifying them, and monitoring them, as well as the period of their appointment. There is a vast amount of data collected and published by both the Government Ministries and regulators. These are housed in libraries both in the UK and France and proved to be valuable resources. The legislation also defines the existence of a public telecommunications, water, gas or electricity 'utility' that often has certain monopoly rights and obligations. Utility companies' metering records are some of the best secondary data sources available to start researching utility metering. With the assistance of the utilities this can be achieved at very little cost. Their customer account files provide information on whether customers have prepayment (slot or card meters) or not, their method of payment (banker's order, direct debit etc.) and whether customers are in arrears with their payments. In practice these files are commercially confidential and are usually presented in consolidated form in published reports for general public consumption.

The information obtained from utilities' records can be combined with surveys that are regularly carried out with utility consumers. An example of this is the *Audit of Great Britain* (AGB), which is carried out on behalf of retailers of domestic goods in the UK, and has some information about metering. Meanwhile, publications from the Government Statistical Office such as *Social Trends* give an insight into the changing consumer attitudes. The press, and even census data, also proved to be useful secondary sources. In addition to these sources, the weekly and monthly journals such as *The Utilities Journal*, *Telecoms Markets* and *Utility Week* as well as newspapers, which analyse and digest the data that is produced from Government, regulators and utilities are invaluable resources to the researcher. The final mode of secondary data generation was through the Internet. This was particularly useful with regard to information on companies from whom primary data was not generated, either because access was not obtained, or time did not permit an in-depth interview.

2.4.2 The Interviews

Due to the different regulatory frameworks in France and the UK, separate approaches in each of the countries were adopted to obtain access to relevant interviewees. The research aimed to obtain data from as many different sources as possible, and these included regulators, meter manufacturers, public utilities, trade associations and communications service companies. A full list of participants is provided in Appendices I and II.

In France, the Government wholly owns and operates the energy utilities as monopolies and it is a large shareholder in France Télécom (the monopoly telecommunications supplier). The primary research sources were the monopoly suppliers themselves, namely; Electricité de France (EdF) for electricity; Gaz de France (GdF) for Gas; and France Télécom (FT) for telecommunications. The supply of water in France is somewhat more complex. Some two-thirds of water supply is provided by the Local Authorities setting up franchises with private operators to supply every site (see section 11.2.3). This may include financing investment and collecting charges. Thus the contacts in this case were made with private operators such as Compagnie Générale des Eaux (CGE) and Suez Lyonnaise des Eaux (SLE). Many of the contacts were obtained by le Centre de Sociologie de l'Innovation de l'École Nationale Supérieure des Mines de Paris (CSI). Through an overseas fieldwork allowance and an ERASMUS-

SOCRATES student exchange, the CSI also provided library and office facilities at their location on le Boulevard Saint Michel in Paris during the nine months' fieldwork period in France (September 1996 – June 1997). Working at the CSI also provided valuable first hand experience of many different theoretical perspectives, in particular the concept of *Techno-Economic Networks* (see section 5.3.3). Other library facilities were made available at France Télécom, Suez Lyonnaise des Eaux and l'Association Technique de l'Industrie du Gaz en France (ATG).

In total, sixteen interviews took place in eight different organisations covering the electricity, gas, water and telecommunications industries in France, A *non-scheduled standard interview* technique as outlined by Richardson *et al.* (1965: pp.45-53) was used. This technique utilised about a dozen questions that provided a framework for a discussion, which lasted on average for an hour, depending on the loquaciousness of the interviewee. The interviews covered three major topics: the regulatory structure of each industry in France; metering policy; and the relationship between metering policy and regulation. The interview data was recorded through the medium of a tape recorder and written notes. The exception to this was Gaz de France who wished to correspond remotely through post, fax and e-mail.

In the UK public utility management is more disaggregated. For example, there are a number individual regulators who have an interest in metering for each industry. This includes the Office of Electricity Regulation (Offer) for electricity, the Office of Gas Supply (Ofgas) for gas and the Office of Telecommunications Licensing (Oftel) for telecommunications. For water there are a number of regulators, Office of Water Services (Ofwat) for economics, the Environmental Authority for the environment and HM Directorate for Drinking Water for public health. There are also numerous privately owned utilities with an active interest in developing metering technology, and each have diverging views and objectives. In the UK, electricity has fifteen distribution companies while England and Wales alone have twenty-one water supply companies. Then there are meter manufacturers such as Siemens and Schlumberger, who act as suppliers to all of the utilities and are crucial in development of technological standards. There are also the communications and software companies who are involved in developing the communications infrastructure, such as Logica, Itron, Ramar and Pilot Systems all of whom contribute to the innovation process. It is noteworthy to point out here that both the meter manufacturers and the software companies are often multi-national, working in both the UK and France. So although the interviews with these parties were carried out in the UK, they did provide valuable insight into their operations in France.

Due to the unbundled nature of public utility management in the UK it was decided to use one contact, namely, The United Kingdom Automatic Meter Reading Association (UKAMRA) as a vehicle for the primary research in the UK. This involved a two-stage process. First an introductory letter accompanied by a brief questionnaire were sent to all members of UKAMRA as well as a number of other interested parties who were not members of UKAMRA. The aim of the questionnaire was primarily to build a framework for the in-depth interviews that followed and also to provide an opportunity to garner opinions from sources who were not selected for interview. A number of respondents also sent in papers and articles that they had written, which added greatly to the source material. After one reminding letter, there were forty-eight replies from ninety-three letters sent out. These questionnaires were followed up by some twenty-four in-depth interviews that were again recorded through the medium of tape recordings and written notes. The interviewees were selected to cover as wide a range of metering issues as possible, including representatives from the electricity, gas, water and telecommunications industries as well as meter manufactures, software companies, consultants and trade associations. Also a range of administrative and management grades were selected. A stratified sample (Cochran, 1977: ch.5 and Hoinville, 1983: pp.58-89) was taken to account for the variation in population. Before both mailing the questionnaire and conducting the interviews a series of pilot studies were undertaken. Six questionnaires were sent out to 'tame' academic and industrial sources who provided comments, criticisms and suggestions. Also interviews were conducted with personal contacts in order to fashion an efficient and robust interview technique before conducting the interviews.

The primary research was concluded with a set of seminars that presented the results of both the primary and secondary research. The seminars took the form of an oral presentation accompanied by a written paper (which in some instances was published) and concluded with a plenary discussion. There were three seminars in total. The first, sponsored by, among others, Electricité de France and ABB (a meter manufacturer) was held on behalf of IPA at the Helsinki University of Technology, Power Systems Laboratory, Espoo, Finland on 19th November 1997. The second was conducted in collaboration with Pilot Systems (a metering communications company) and IPA as part of IIR's (a conference management company) 2nd Metering In The Utilities Conference, on 25th March 1998, London, England. The third was held at the UKAMRA seminar entitled 'Automatic Meter Reading the Business Case', conducted at the University of Warwick, England, on 8th May 1998. Participants at these seminars are shown in Appendix III. Other opportunities to present aspects on both the operational and theoretical basis of the research arose at The Epistemology Group's seminar on 'The Evolution of Knowledge and Invention' at the University of Sussex on 10th June 1997, and annual seminar presentations to The Department of Business Studies at The University of Edinburgh.

2.4.3 The Physical Artefacts

The final area of primary data was generated from the study of the technological artefacts themselves. This was done by observing the continuities and differences between metering and communications technologies in the industry sectors. Analysis of the technological innovations in these instruments give a clue to their changing role within the larger public utility systems infrastructure. Thus a dossier of meter designs and specifications was compiled.

2.4.4 The Direct and Participant Observations

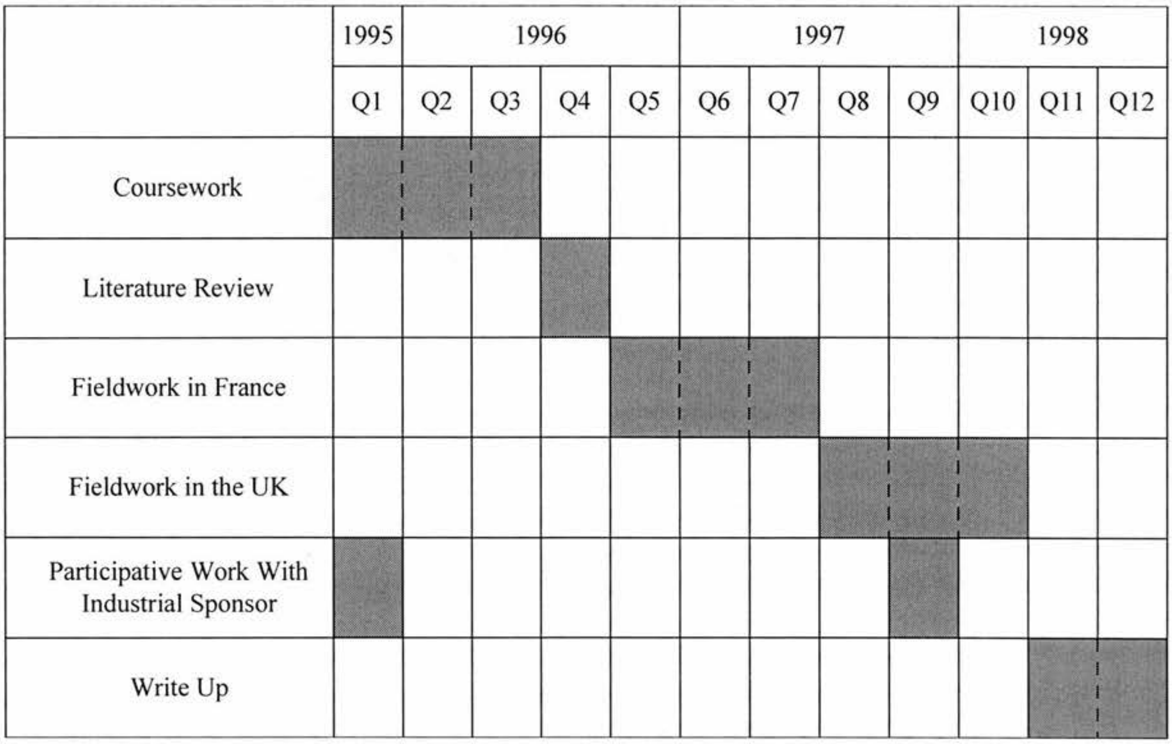
In addition to the formal generation of data from primary and secondary sources, much of the insight in the project has been gained from prior experience of working in the public utility sector. Much of this is outlined in section 2.2, and this has laid the grounding to not only the formulation of the project, but also the understanding of the principles behind the economics, human resource, financial and engineering issues which contribute to public utility management.

During the time of the project, fieldwork has not only been confined to the aforesaid activities. There has also been work done in conjunction with IPA. This has included the appraisal of short term price forecasting computer software for the England and Wales Electricity Pool (a half hourly electricity spot market, see sections 6.2.1 and 6.2.2). Work has also been carried out on the evaluation of the pumped storage business of the National Grid Company (Dinorwig & Ffestiniog, North Wales, see section 6.2.3). This has meant that a direct participative component is incorporated in the project methodology.

2.4.5 The Project Management

The research work has been monitored by standard project management techniques a GANTT chart of which is shown in figure 1. Milestones included completing; the project proposal (March 1995), the training (June 1996), the literature review (October 1996), the French fieldwork (June 1997), the UK fieldwork (March 1998) and the first draft of the thesis (September 1998). The project was monitored by means of regular work in progress meetings with both company and academic supervisors. In addition to the regular project management procedures, a diary was kept to account for the work undertaken in the project. This diary together with the taped interviews, written transcripts, notes made from secondary research sources and bibliography of references, make up the database for the project.

Figure 1: Project GANTT Chart



2.5 THE ANALYSIS

2.5.1 The Mode of Analysis

The analysis of the project was conducted in three stages. The first involved evaluating all of the secondary material that was gathered during the project and this was combined with the direct experience gained from working in public utilities for previous working experience. The second process involved combining the primary interviews with the secondary material to present the exploratory case studies presented in chapters 6 to 13 (Part II). The third was the application of the theoretical perspectives discussed in chapters 3 to 5, to the case studies to produce cross-case study comparisons which describe and explain the phenomena as well as prescribe a technology and regulation policy in chapters 14 to 17 (Part III). There is a clear delineation in the thesis between the explorative nature of the case studies of Part II and the descriptive, explanatory and prescriptive nature of Part III. Although it may be possible, in principle, to combine description, explanation and theory it requires immense skill, and in this thesis that was thought impractical. The major concern was that since this is an academic piece of work the audience for the research would not necessarily be familiar with the industries being described in the case studies. Moreover, the explanatory and prescriptive analysis was constructed through the perspective of not just one but a number of theoretical approaches. This makes the format of the analysis phase simpler to understand and clearer for the reader who is not familiar with either the industries being discussed or the theoretical perspectives taken.

2.5.2 The Analysis of Secondary Material

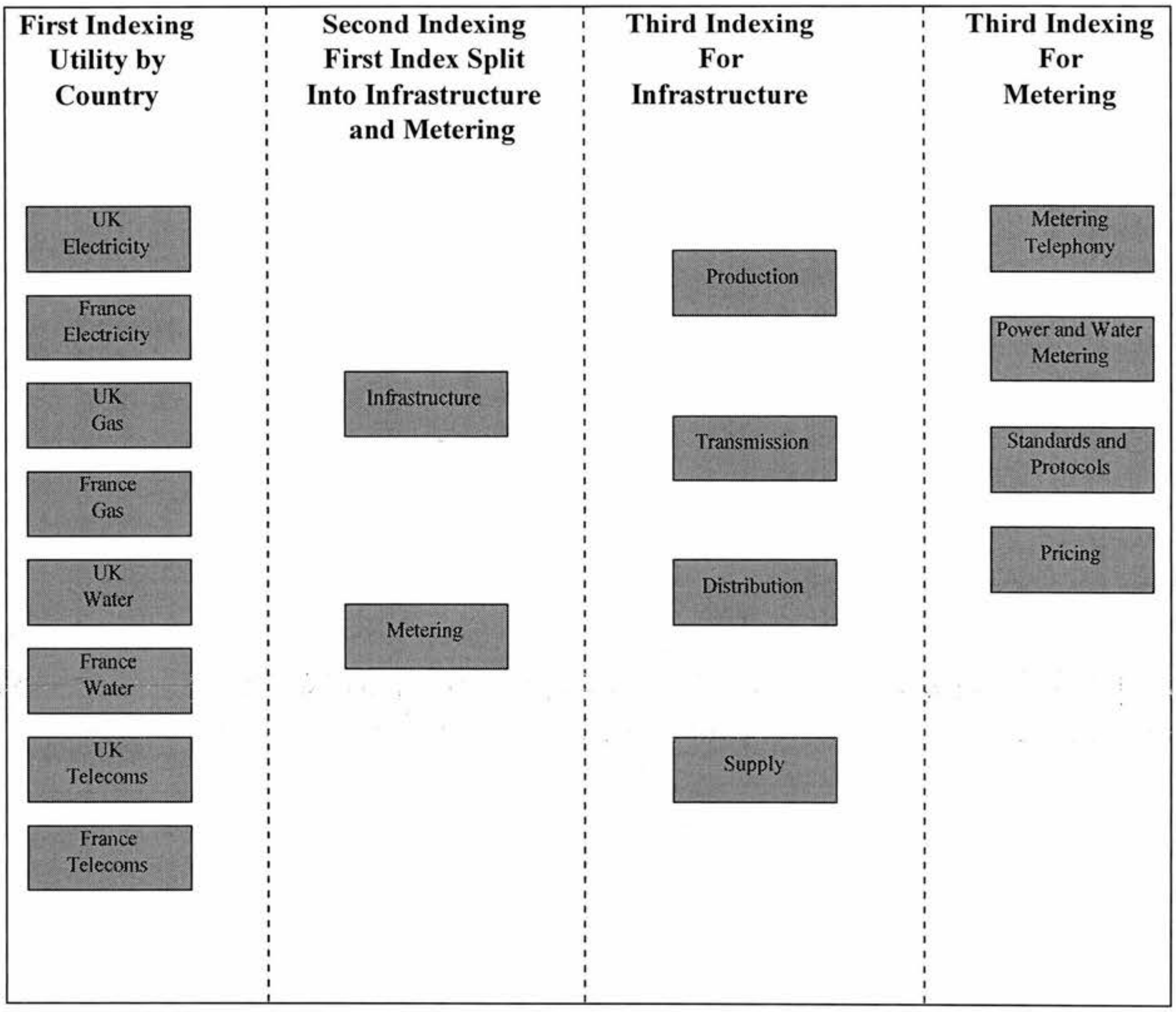
The collection of secondary data provided the foundations of the case studies and provided a basis to construct interview questions in the primary research. As described in section 2.4.1, a considerable amount of secondary research was required prior to the interview stage of the project. Nonetheless this was taken forward to provide the exploratory framework for the eight case studies. A general format was used to maintain continuity between case studies but there were also differences. Each case study has unique features in that different issues pertain to different industries in the two countries studied. Archive material is used to place historical evidence into its contemporary setting. A description is then made of the network and regulatory infrastructure, exploring how it has altered during the twenty-year case study period. The role that metering has played in the development each utility infrastructure is then considered. The exception to this format is in the both of the telecommunications case studies (chapters 12 and 13). Since modern metering is an integrated data processing and a communications device, in the telecommunications case studies not only is the metering of telephony analysed, but also the communications technology used in energy and water metering.

2.5.3 The Analysis of Primary Material

The process of analysing the primary material including the questionnaire survey, the interviews, the participative research and evidence from the artefacts (the meters and communications media) themselves, involved a process of transcription and blending with the secondary material, to create the case studies. The multiple sources of evidence were first of all transcribed into a written format and stored on the project database. For example, it took about eight hours to transcribe forty-five minutes' worth of interview. The material then was indexed according to the relevance it had to each of the eight case studies. This was followed by a number of sub-indexing routines. These sub-indexes roughly corresponded to the sections and subsections of the case studies. For example, the first sub-indexes were on issues such as industry history, regulatory infrastructure and metering. These were then further subdivided in the indexing tree shown stylised in figure 2.

At this point in the analysis it was thought that it might have been useful to use a computer package to undertake the indexing. In the event it was done manually. Since all the data generation, analysis and presentation was conducted by one person (myself) it was felt that there were textures in the interviews which could only be gained from a combination of the written transcriptions and personal recall together, which would be lost in a qualitative research package. Moreover, as analysis of the primary material was made manually, more insights were revealed and an iterative method of indexing developed. This valuable process would not have been achieved if indexing parameters had been defined prior to the analysis, and programmed into a software package. Once the indexing of the transcribed material had been completed the process began to combine the primary and secondary research into the final case study. The formats of the case studies are split into a commentary and vignettes. The commentary is composed from a mixture of secondary and primary material while the vignettes are composed mostly from primary material. In the vignettes direct quotes are enclosed in inverted commas and paraphrasing is not enclosed in inverted commas. In this way the continuity of the case study description is maintained while the reader can see which statements were generated from personal interviews. Each vignette is coded to specific interviews, the transcriptions of which are given in Appendix IV.

Figure 2: Indexing of the Primary Material



2.5.4 The Descriptive, Explanatory and Policy Analysis

The final part of the thesis takes the theory described in Part I and combines it with the exploratory case studies in Part II to produce pattern matching, build explanations and recommend policy. The pattern matching is achieved through cross-case study comparisons at three levels. First, at the *macro* scale level the role of information technology is considered. In particular the validity of *Techno-Economic Paradigm* is tested. The analysis then considers the changes in network infrastructure caused by technology and regulatory change. Here a number of approaches are taken to describe and explain the phenomena explored in the case studies and their merits discussed. Finally, using the insights gained from the explanation building, policies are determined both for regulation and metering on the energy, water and telecommunications sectors.

2.6 SUMMARY

The methodology described in this chapter is founded on multiple case studies that take the logical progression of exploratory, descriptive and explanatory form that can be described as an 'emergent grounded' approach. This holistic research design includes documentary sources, archival records, questionnaires, interviews, direct observations, participative observations and evidence taken from the physical artefacts (the meters themselves). This case study research design is aimed at satisfying the *internal*, *external* and *construct validity* that are recognised to be the criteria that are needed to judge a robust research design. The research also relies on direct experience that the author has in operational and management roles in public utilities. The analysis departs from *grounded theory* in that the research is founded on questions that were formulated during this period of employment. This grounding was further crystallised in the study of regulation, technology and methodological theory during the literature review that took place prior to the fieldwork in the first year of the research. In saying this, the fieldwork design followed in principle the guidelines of *grounded theory*. Although the questionnaire and interview questions were based on extensive preparatory reading they were as unstructured as practicable to allow the inquiry to be as free from 'grand theory' as possible. In this sense the case study accounts are theory free. 'Theories' in the study are used in a phenomenological sense. They are also considered to be important evaluation mechanisms in that they provide a common framework from which a phenomenon can be examined. In other words a 'theory' is seen as an approach of conceptualising the world which is constructed from assumptions that are in turn derived by empirical testing and logic. Thus the independent analysis of a number of 'theories' provides different and contrasting insights into the phenomena being studied. These insights can then in turn be used to guide policy making.

CHAPTER 3

REGULATION THEORY

3.1 INTRODUCTION

Regulation is defined (see the definitions page at the start of the thesis) to be a homeostatic system or a number of interacting systems (*Régulation)* which are equilibrated by a set of rules (*réglementation)* that involve a complex of 'social' and 'non-social' processes. This first section of this chapter will outline some of the systems of regulation that are relevant to public utilities and the rules that are used to account for imbalances or asymmetries with these systems. The regulatory systems considered are market theories of regulation, social theories of regulation and technical theories of regulation. This way of approaching regulatory theory is known as 'public-interest' theories of regulation (Crew & Kleindorfer, 1986). They stem from the notion that regulation aims to discharge the 'public interest' (e.g. justice, safety etc.). In order to implement these systems some form of institution or bureaucracy is required, and it is this subject which will be addressed in the second section. In relation to public utilities these institutions may be conducted by Government (local, national or international) headed by politicians or delegated to quasi-independent regulators run by experts. The areas of responsibility of institutions include national and strategic systems of innovation to those institutions that are responsible for the overseeing of economic and social well being. One of the issues that arises with the creation of regulatory institutions who work in the 'public interest' is their accountability. Bonbright (1961) suggests that the term 'public interest' is itself vague and that it "is more often assumed rather than articulated." Accordingly, in place of the public-interest theories, several 'private-interest' theories have been proposed and they will be discussed in the third section of this chapter. 'Private-interest' theories seek to explain the origins of regulation for those who see themselves *ex ante* as beneficiaries of the regulatory system.

3.2 PUBLIC INTEREST THEORIES OF REGULATION

3.2.1 Market Theories of Regulation

One branch of regulatory theory espouses the works of Adam Smith, in *The Wealth of Nations* (1776: summarised in Samuelson & Nordhaus, 1985) who recognised a system of regulation in economics and proclaimed it in the principle of the 'invisible hand'. It states that every individual is selfishly pursuing only their personal good, which is dictated by the rules of supply and demand. Despite some short-run inequalities, it is argued that in the long-run this system will prove to provide the best good of all and any intervention would almost certainly be injurious.

Some of the modern advocates of the philosophy are the *Chicago* and *Austrian Schools*. The Chicago School believes that a fixed growth rate in money (say 3 or 4 per cent per annum) and a free market are all that is required to produce a sustainable economy (Samuelson & Nordhaus, 1985). The *Austrian School* (Littlechild, 1986) sees competition as a dynamic process of discovery and co-ordination, instead of a static state of general equilibrium. In these philosophies entrepreneurial profit plays a vital role in stimulating alertness to new opportunities. Market devices such as product differentiation and advertising are fully consistent with the competitive market process. *Austrian* economics casts doubt on the ability of any human being, Government or private organisation to acquire the knowledge necessary to improve upon the market. Effective Government policies are considered to be the reduction of entry barriers and development of private property rights. It is also claimed that consumers also benefit from less extensive patent and copyright laws as well as inhibiting the development of private monopolies or cartels, and by abolishing the monopoly of many nationalised industries. Privatisation is seen to increase the role of market forces vis-à-vis political forces. Factors like the environment, health, safety, geography and demography are therefore more effectively dealt with by making producers legally liable for them, and by creating property rights to be traded on markets, rather than by cost-benefit analysis or 'externality taxes'.

Two concepts have dogged this market view of regulation, namely, imperfect competition and exclusion of social externalities.

Imperfect competition is particularly pertinent in public utilities and arises when only a few firms are able to supply a specific product at the going price. This may be caused by, amongst other reasons, barriers to competition such as patents, collusion in cartels, monopolistic competition due to product differentiation, or significant economies of scale. Externalities on the other hand, are spillover effects when production or consumption inflicts incidental costs or benefits on others. This is often known as the 'tar baby effect', that is, that a cost (or benefit) due to regulation may have a benefit (or cost) elsewhere in the economy (Crew & Kleindorfer, 1986: pp203-209).

Another crucial argument against considering regulation in a perfectly competitive mode of thinking is that 'supply and demand' in many cases does not act in a smooth fashion and is often 'sticky'. This was most notably illustrated by John Maynard Keynes's *magnum opus*, the *General Theory of Employment Interest and Money* (1936; summarised in Ekelund & Hebert, 1975: p.409). According to Keynes, wages and prices do not react flexibly to price supply and demand and are constrained by social factors distorting the aggregate supply curve. It was this policy that has encouraged the use of instruments other than money, such as the fiscal policy of Government spending and taxation, to stimulate growth, particularly when the economy is stuck in recession.

Also, the presence of social castes is one of the major concerns of J.K. Galbraith in *The Affluent Society* (1970: chs.7 & 12). In his analysis he argues that the negative effects of inequalities, incumbent advantage and vested interests in society, should be factored-in to any policy. Social regulations are consequently required to counter these imbalances in society, in addition to counter imperfections in competition and externalities.

3.2.2 Social Formulations of Regulation

Taking into account the imperfect nature of competition, regulation cannot be left to market processes alone. Indeed, in a classic study of business regulation, M.H. Bernstein wrote that the:

"Determination of regulatory goals does not result inevitably from the logical analysis of certain economic facts, nor is it automatically deduced from a set of propositions concerning the nature of the political state and the proper boundaries of political action in a democratic society." (Bernstein, 1955: p.258)

Reagan (1987: ch.2) adds that regulatory goals cannot be deduced from specific principles, either. He suggests that it is not that economics, political science, and the physical sciences are irrelevant to regulatory policy-making, rather that they are not decisive in themselves, but they merely illuminate choices, not decide them. Reagan then concludes that:

"Economic activity is not always channelled to the optimal satisfaction of public needs by very imperfect competition among industrial giants, or by the narrow incentives that press on marginal firms in the most competitive sectors; and a free society will therefore sometimes find it advisable to turn to Government as the instrument for making the economy serve us as whole persons, not only as 'economic man (or woman)'."

Therefore, Reagan argues that regulatory agencies should be accountable to the electorate through the active participation of interested citizens as advocates of their preferred policies.

Nikolai Bukharin developed a scientific analysis of a socially ideal (but not democratic) State in his general sociological work on *Historical Materialism* (1969). He treats society as a system of unstable equilibrium inside which the State functions as a 'regulator' and attempts to manage or absorb contradictions between the productive forces and production relations and/or between the economic base as a whole and the various elements of the superstructure (Jessop, 1982: p.18). This Marxist regulatory structure is developed further by Elmar Altvater who specifies four social preconditions of capitalism that cannot be secured through competition among particular capitals, and must therefore be guaranteed through the actions of the State as an 'ideal collective capitalist'. These social conditions are: the implementation of the general material conditions of production (or infrastructure); the creation and enforcement of the bourgeois legal order; the regulation of the conflict between capital and wage labour; and the promotion of the total national capital in the capitalist world market (Jessop, 1982: p.91).

One of the notable theories of regulation within this tradition is the *Paris* or *French School* of Regulation. In *A Theory of Capitalist Regulation,* Michel Aglietta (1979) describes how regulation theory is founded on the scientific principle of equilibrium and balance between production and consumption (see also Boyer 1988a and Boyer 1988b). The factors influencing this balance are driven by social change, which are in turn determined primarily by the wage/labour relationship. This creates a new *régime of régulation* defined by new rules, in the shape of different social norms and working practices. Using this hypothesis and taking as an example the United States economy, he describes how the economy has gone through four phases of evolution since the end of The American Civil War. Each phase lasted about fifty years and was characterised by an economic cycle of growth and collapse, due to a specific wage/labour relationship:

Phase I

Aglietta argues that the extensive accumulation governed by the competitive mode of regulation seen between 1850 and 1900 was driven by rapid industrialisation supplemented by immigrant labour in the United States. Growth was founded on the expansion of markets, the opening up of the 'West' in the case of the United States, and colonial possessions in the case of European States.

Phase II

In the period 1900 to 1950 he suggests the relation between labour and production changed significantly. This was the period of intensive accumulation governed by competitive regulation. The supply of labour through immigration slowed, while the power and expectations of the labour force grew. The production process responded by the introduction of 'Taylorist' and 'Fordist' methods of working, that resulted in large intensive industries such as steel, automobile and textile manufacture.

Phase III

The Great Depression and finally World War Two heralded the end of Phase II of regulation that was to be replaced by intensive accumulation governed by monopoly regulation. This is characterised by an increase of accumulation in consumption, paid for by Government investment and driven by health care, welfare, education and technological initiatives.

Phase IV

Due to a series of recessions during the nineteen-seventies and nineteen-eighties, the *Paris* or *French School* believes the economy needs to develop a new 'Post-Fordist' approach to the interplay between labour and production, where flexible lean production is combined with a more flexible workforce. This vision is most clearly represented by Alain Lipietz (1992) in his definition of a new economic order (or 'habitus') combining 'Post-Fordism' with many of the modern social concerns such as the environment.

Not surprisingly, since the *Paris or French School* has its roots in Marxist thought, it does not accept the principle of the 'marginal efficiency of capital', (Aglietta, 1979: p.357) which contrasts it with neo-classical market economics. Moreover, the rights of the collective are paramount, leaving no room for individual and private property rights, which is intrinsic to the *Austrian* theory of regulation previously described. In addition, its primary emphasis is on the wage/labour relationship at the expense of innovation (Boyer, 1988a pp.3-25) and the imperfect and asymmetric nature of knowledge (Irwin, 1984 and Mayer, 1995: pp.138-159).

3.2.3 Technology in Regulation Theory

Expertise and knowledge is the topic of interest for Fincham *et al.* (1994) in the widening scope and use of information technology in the financial services sector. Their argument hinges on the need to manage knowledge and expertise, particularly the ability to integrate detailed technological expertise that equates with the new industrial order that is tempered by the knowledge base. Thus constructed, knowledge, whether it be of processes or technological artefacts themselves can result in a disequilibrium which requires compensation by new regulation. Probably the most developed theory in this philosophy is the *Techno-Economic Paradigm* that has been proposed by the Venezuelan economist Carlota Perez (1983). In introducing this concept, she wished to draw attention to the fact that some changes in technology are so far-reaching that they affect almost every industry and service throughout the system, and change the design and management functions everywhere in the economy.

The origin of the *Techno-Economic Paradigm* derives from Joseph Schumpeter's later theories developed in *Capitalism, Socialism and Democracy* (Schumpeter, 1943) and the identification of business cycles or *Kondratieff Long Waves* in which the economy runs in approximately fifty year cycles of economic growth and recession (Freeman & Soete, 1997: ch.3). Nonetheless, Samuelson & Nordhaus (1985: pp.793-800) point out that there are many factors both internal and external to the economy, which explain the major cycles including investment, technological innovation, dynamic changes in population etc. However, Freeman & Perez (1988) believe that most theories of economic growth fail to take account of the specifics of technology in each historical period. They divide patterns of innovation into four definitive groups:

First, *incremental innovations* occur from continuous activity which have a significant cumulative effect on growth and result from redesigned products or processes usually involving existing products or services. They often do not occur as deliberate research and development but are improvements suggested by users or consumers. Second, *radical innovations* are discontinuous events often as a result of formal research and development. These are usually industry specific innovations such as nuclear power in electricity generation or the manufacture of nylon in the chemicals industry. Third, *new technology systems* occur when clusters of innovations (both incremental and radical) occur together, leading to the rise of several whole new industries such as petro-chemicals and synthetic materials. Finally, changes in the *Techno-Economic Paradigm* occur when technology systems are so fundamental in their effects that they alter the organisation and structure of the whole economy. By paradigm they mean:

"A radical transformation of the prevailing engineering and managerial common sense for best productivity and most profitable practice."

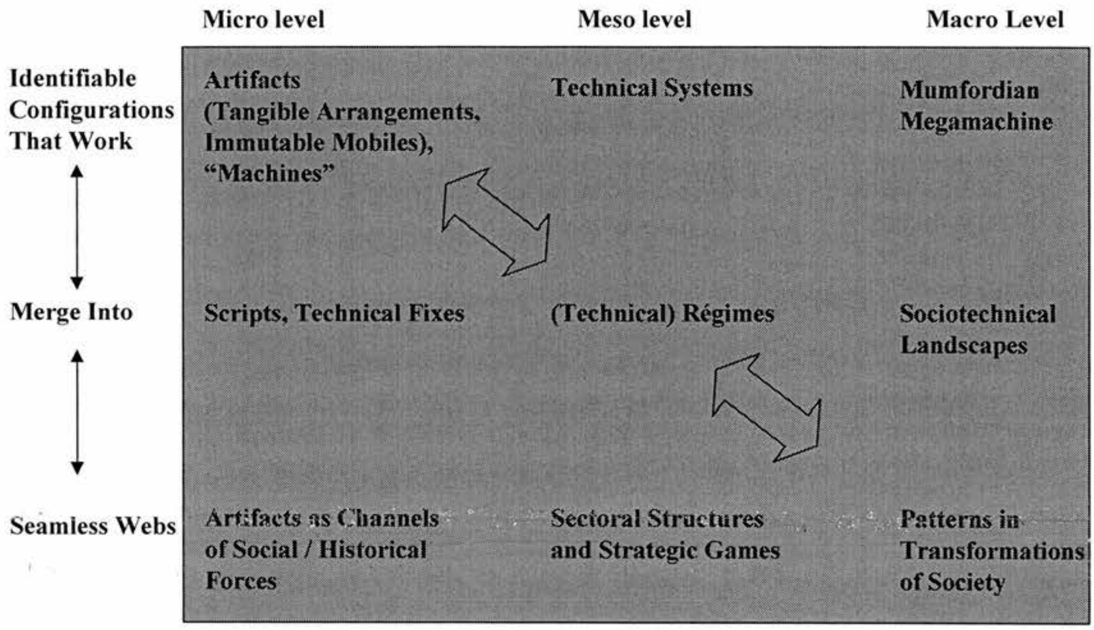
The process of computerisation, it is claimed by Freeman (1993), is based on one of these order-of-magnitude changes. He argues that the costs and ease of processing, storing and transmitting information, is associated with fundamental changes in the organisation of production, design, distribution and administration. At the technical level, there is a cluster of still-continuing radical and incremental innovations in semi-conductors, integrated circuits, optical fibres, telecommunications, computer hardware and software as well as many related products and services. In some ways it is analogous to previous waves of technical change that have affected numerous industries and services throughout the economy, such as steam power, electric power or oil-based mass-production systems. It is thus concluded that the interdependencies between clusters of technical innovations, between technical and organisational innovations and between organisational innovations and wider institutional changes cannot be ignored. Freeman & Perez (1988) go on to suggest that there have been five waves of upswing and downswing.

The first wave was from the seventeen-seventies to the eighteen-forties with the early mechanisation of textiles and iron working, driven by water transportation and power. The second wave was from the eighteen-forties to the eighteen-nineties when steam power took over and this was manifest by rapid industrialisation due to a growth in the coal and transport industries. The third wave was from the eighteen-nineties to the nineteen-forties when the reduced cost of steel production resulted in developments in heavy industry such as shipbuilding, electricity distribution and the chemicals industry. The fourth wave was from nineteen-forties to the nineteen-eighties where the combination of new types of 'Fordist' mass production and abundant low cost energy (oil, gas, and electricity) resulted in the mass consumer goods of automobiles, refrigerators and synthetic materials. The fifth wave from nineteen-eighties onwards is driven by microprocessor electronics, which is delivering us into the information and communications age.

Perez (1983) has pointed out that the social and institutional framework that is hospitable to one set of technologies will not be suitable for a radically new technology.

Whereas *incremental innovations* can be easily accommodated, this may not be the case with *radical innovations*, which by definition involve an element of creative destruction. When we are talking about large clusters of *radical innovations* combined with the rapid progress of *incremental innovation*, then the problems of structural and social adjustment can be very great. This is quite obvious when such aspects as the changes in management techniques and skill-mix which are called for, but it also applies to many other types of institutional change in standards, patents, new services, new infrastructure, Government policies and public organisations.

Figure 3: A Diagrammatic Representation Showing the Different Levels of Technological Analysis. The *Macro* Levels are Addressed by The *Techno-Economic Paradigm*. The More *Meso* Level is Addressed by Approaches Described in Chapter 5.



Rip & Kemp (1998: p.388)

Green *et al.* (1999) argue that since *Techno-Economic Paradigms* focus on the regulatory issues arising from the diffusion of highly 'pervasive' generic technologies they as a result tend to be techno-centric. They argue other approaches incorporating social and economic as well as technical factors are also required to study what is referred to as the '*meso-level techno-economic*'. This view is summarised by Rip & Kemp (1998) who visualise these linkages in figure 3. At the *micro* level there are artefacts, at the *meso* level there are *technical régimes* and at the macro level there are patterns in transformations in society such as the *Techno-Economic Paradigm*. The *technical régime* is considered to be the surrounding environment that affects the take up of a technology. Some of the more *meso* approaches are examined further through the notions of *Techno-Economic Networks, Sociotechnical Constituencies* and *Evolutionary Theory* in chapter 5.

Freeman and Perez's hypothesis has features of the *Paris or French School* in its attempt to account for cyclical waves of economic growth, and with the *Austrian School* (somewhat surprisingly) in its interests in the dynamics of knowledge. However, there are significant differences. The growing recognition of the importance of organisational and managerial change ('multi-skilling', 'lean production systems', 'just-in-time' stock control, worker participation in technical change, quality circles and continuous learning, etc., etc.) can only be brought about by competition and the rites of the individual, according to *Austrian* theory. This same process on the other hand is seen as an overtly political process according to the *Paris or French School* and the *Techno-Economic Paradigm*. Social well being and the understanding of organisation dynamics are key factors in the case of the *Paris or French School* while competition and technology are the key factors in the *Austrian* and *Techno-Economic Paradigm* respectively. Freeman (1988: pp.11-12) and Boyer (1988b: pp.89-90) suggest that the *Paris or French School* and the *Techno-Economic Paradigm* are sufficiently complimentary for an original thesis. Yet the *Paris or French School's* preoccupation with the wage/labour relationship at the expense of the technology, and their different treatment of the dynamics of knowledge lead to the conclusion in this thesis that *Techno-Economic Paradigm* and the *Paris or French School* address differing regulatory régimes. Table 2 outlines the continuities and differences of the three theories.

Table 2: A Comparison between the Regulatory Schools

School of Regulation	Societal Emphasis	Major Asymmetries Affecting Regulation	State of Knowledge
Austrian	Individual	Market Mechanisms	Imperfect
Paris or French	Collective	Wage/Labour Relationship	Perfect
Techno-Economic Paradigm	Collective	Technology and Innovation	Imperfect

3.3 REGULATORY INSTUTIONS

One of the key components to the notion of 'public interest' theories of regulation described in the previous section is that institutions require to be created to take into account a number of constraints. These constraints include social welfare (e.g. health and equality), physical constraints (e.g. geography, resources), knowledge asymmetries and technology as well as consumers' and workers' rights. In a market orientated environment, regulatory institutions also require to develop rules to maintain a competitive environment and monitor monopolies and cartels. The rules that maintain these regulatory systems are found in legal documents such as Acts of Parliament, company licences, patents, standards and protocols.

Social welfare has historically been the responsibility of Central Government or publicly run companies (Henney, 1994). One of the key issues involved in the liberalisation of public utilities is to ensure that there is no regulatory deficit in this matter. Garret (1998) highlights that such issues as customer service standards and universal access at equal cost, either require to be incorporated in company licences or taxes required to be raised to account for social welfare that may be compromised by privatisation. Also the exploration and production of energy resources involves the issuing of licences usually by the national government. This ensures that natural resources are not over exploited and environmental pollution is minimised (Cameron, 1995). Meanwhile workers' rights are enshrined in employment legislation that must ensure a balance between exploitation of the workforce and economic efficiency that is at the core of the *Paris or French School* of regulation.

Some of the forms of regulatory institutions can be distinguished by using Boyer's (1999) definitions of the varieties of capitalism that he divides into four categories: market led capitalism, company led capitalism, socio-democratic régimes and State led capitalism. Each of these forms of capitalism creates it own and very characteristic institutions.

Market led capitalism, which Boyer (1999) suggests is popular in the English speaking countries, is characterised by a faith in private ownership and competition. Here institutions need to be formed to regulate free trade. The Office of Fair Trading and the Monopolies and Mergers Commission in the UK are examples of these semi-autonomous bodies (appointed by, but acting independently from, the government). It is ironic that as 'deregulation' takes place regulatory institutions require to be created (see Harper, 1989; Henney, 1994; O'Neill 1996, Surrey, 1996 and Chapters 6, 8, 10 and 12).

In company led capitalism there is a central role for the large corporation. This, it is argued by Boyer (1999), characterises the Japanese economy and is dominated by a close interrelation between different industries and government. Therefore this system is strong in co-ordinating complex production processes but weak in the service industries and industries which are driven by scientific innovation.

In the Nordic countries, Boyer (1999) argues that the pursuit of the public interest and social justice means that socio-democratic régimes permeate nearly all political institutions. The institutions such as education, social services and trade have a complimentary architecture. In these countries there is less interest in private ownership and large corporate institutions.

In State led capitalism the 'laisser-faire' is not accepted and public intervention is common in all sectors of industry. Boyer (1999) gives France as an example of this form of capitalism and it is characterised by large nationally run systems that define industrial and technological systems of innovation.

Freeman (1995) and Freeman & Soete (1997: ch.12) argue that national and regional innovation systems are essential in that they derive the networks of relationships for innovation. Chesnais (1993) describes how this is characterised in France by:

- the organisation and funding of the largest part of fundamental research by the State (The National Centre for Scientific Research, CNRS);
- an administrative elite of engineers, managers and politicians educated through the *Grandes Ecoles*;
- and a pervasive element of State involvement in its industrial, scientific and technological processes known as *dirigisme*.

Mustar (1994) and Oakley (1990) describe how the *dirigisme* of the French State has evolved from Jean-Baptiste Colbert (1643-1715) who founded the French Académie Royale des Sciences in 1676. This interventionist policy was particularly manifest in the years after World War II up until the late nineteen-seventies with the development of *Grandes Projects*. In the utility sector this involved the formation of the CNRS, the Centre for the Study of Telecommunications (CNET) and Commissariat à l'Energie (CEA). These years saw remarkable achievements in, for example, avionics (Concorde) and nuclear power generation. Mustar also suggests that this Colberstist policy, although still present, has gone through a change in emphasis during the nineteen-eighties. These reforms have been driven by increased international trading, European Union harmonisation and the maintenance of international competitiveness. Chesnais (1995: p.193) concludes that despite the French system's numerous achievements, this cannot hide serious weaknesses such as its strong rigidity that finds it difficult to cope with contemporary requirements for technological change and a lack of co-ordination between science and industry.

In the UK a different approach has been adopted. Walker (1995) describes that in the period from the end of World War II until the nineteen-eighties, there was the promotion of State sponsored support in industry (including public utilities) and research and development. The position however changed during the nineteen eighties with a number of reforms which encouraged a market economy based on competition, such as, private ownership, the foundation of monetary instruments as the foundation of macroeconomic policy, constraints in public expenditure and restrictions on trade union power. These changes in policies were seen as a response to the perceived failure of the previous interventionist policies and the increasing international dimension of national economies. Freeman (1995) and Freeman & Soete (1997: pp.306-312) while acknowledging that international connections are of growing importance, stress that *National Systems of Innovation* are still relevant. In particular they see the influence of education, industrial relations, research, cultural traditions and geopolitical policies are still fundamental. Indeed they go further and suggest that because of these factors they consider that *National Systems of Innovation* are more crucial today in defining regulatory policy.

3.4 PRIVATE-INTEREST THEORIES OF REGULATION

The major area of criticism of 'public-interest' theories of regulation and the institutions that are created is, as stated earlier, their accountability. As a result 'private-interest' theories of regulation have arisen in regulation theory to explain those who see themselves as *ex ante* beneficiaries of the regulatory régime. The best known of the 'private-interest' theories is the 'capture' theory Peltzman (1976). Here regulation is viewed as a product in that it provides an individual or organisation with the opportunity to impose their own private interests. Proponents of the theory would cite examples of how industries have lobbied to be privatised as monopolies to avoid the rigours of competition. 'Capture' can also be seen from the academic point of view in that the proponents of the *Austrian* (market processes), *Paris or French School* (social process) and the *Techno-Economic Paradigm* (technical process) provide different insights into the regulatory process. However if one approach is considered on its own (or 'captures' the academic process) this in turn can give an unbalanced appraisal of regulatory process.

Niskanen (1971 and 1973) studies regulatory 'capture' in terms of the behaviour of bureaucracies or hierarchies. He defines a bureau as being an institution that does not depend upon the success of the organisation. This is crucial when considering the accountability of regulatory institutions or publicly run organisations. Lindsay (1976) argues that an institution of regulation is based upon the output that is measurable and this may include social aims that are difficult to account for. Thus a bureaucratic theory implies that an institution may be 'captured' by bureaucrats (companies, tycoons, trade unions, academics, civil servants, politicians etc.) to serve the ends of the bureaucracy which may not be consistent with the original intentions behind the institution's creation.

3.5 CONCLUSION

Regulation is the term used to describe the systems and rules involved in maintaining a social equality, the maintenance of the market mechanisms, knowledge asymmetries, technological innovation and so on. It is concluded that by its inherent nature one approach alone (*Austrian, Paris or French School, or Techno-Economic Paradigm)* is unable to provide a comprehensive appraisal of the regulatory process. Rather they are studying separate but interacting and overlapping *régimes of regulation.* Since this thesis is studying the interrelation of innovation on regulation, it is the role of the *Techno-Economic Paradigm* and other sociotechnical techniques[1] that are examined further in later chapters. This chapter has also examined some of the regulatory institutions that are created in the 'public interest'. During the nineteen-eighties there has been a divergence on policy towards regulation in France and the United Kingdom. The United Kingdom has placed greater faith in market mechanisms and private property rights. In France meanwhile a policy of State intervention and collective control has largely been maintained. Either way regulatory institutions are required to oversee economic, social and technical concerns. These institutions range from watchdogs to monitor such issues as 'fair trading', 'social obligations' to *National Systems of Innovation* and direct Government intervention. In addition it has been found that although necessary, these regulatory institutions have limitations. 'Private-interest' theories of regulation act to counterbalance the fact that regulatory institutions require some form of accountability since the regulatory process can be 'captured' by (often well meaning) individuals or organisations for their own gain. The following chapter will now go on to focus more closely on the regulatory institutions that are pertinent to public utilities.

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[1] See chapter 5 for an analysis of *Techno-Economic Networks, Sociotechnical Constituencies* and *Evolutionary Approaches*.

CHAPTER 4

THE ROLE OF METERING TECHNOLOGY IN PUBLIC UTILITY MANAGEMENT

4.1 INTRODUCTION

The features defining a public utility are those that give rise to economies of scale resulting in their 'natural monopoly' position. The point is intuitively obvious. There are definite cost savings in having only one water main in the street, and similarly with other utilities such as electricity, telecommunications and gas. Such economies of scale lead to the fundamental problem of public utility economics: how to establish institutional arrangements that will take advantage of these economies of scale but will not involve monopolistic excesses. This problem is not typically left to the operation of unregulated markets, although several innovative proposals have been made for at least the partial deregulation of utilities in recent years (Crew & Kleindorfer, 1986: p.3).

There is also a body of legal and historical precedent to support the view that an industry must be of some public or social significance to be considered a public utility (Brown & Sibley, 1986: p.6). The strategic and political importance of gas, electricity, telephone and water have always been present in the management of utilities (Headrick, 1991). Moreover, the concept of universal access at equal cost has been a particular theme in the supply of utilities as a social right, rather than chosen luxury, over the past fifty years.

Crew & Kleindorfer (1986) also suggest that one of the features that give rise to the 'natural monopoly' position of utilities is technology. The large capital investment in generating, storage, transmission and distribution facilities that need to be built may last up to one hundred years in some cases (Lee, 1969). These special technological features of the system therefore require harmonisation with the economic and social factors.

The first section of this chapter will examine the role that metering has in the management of public utilities. This will be followed by an outline of the social and technical constraints on utility regulation in the electricity, gas, water and telecommunications industries. It will then go on to outline some of various forms that utility regulation can take. This is described within the framework of the *Principal-Agent* model. The chapter concludes by suggesting that information technology and metering have key roles in changing the system of regulation.

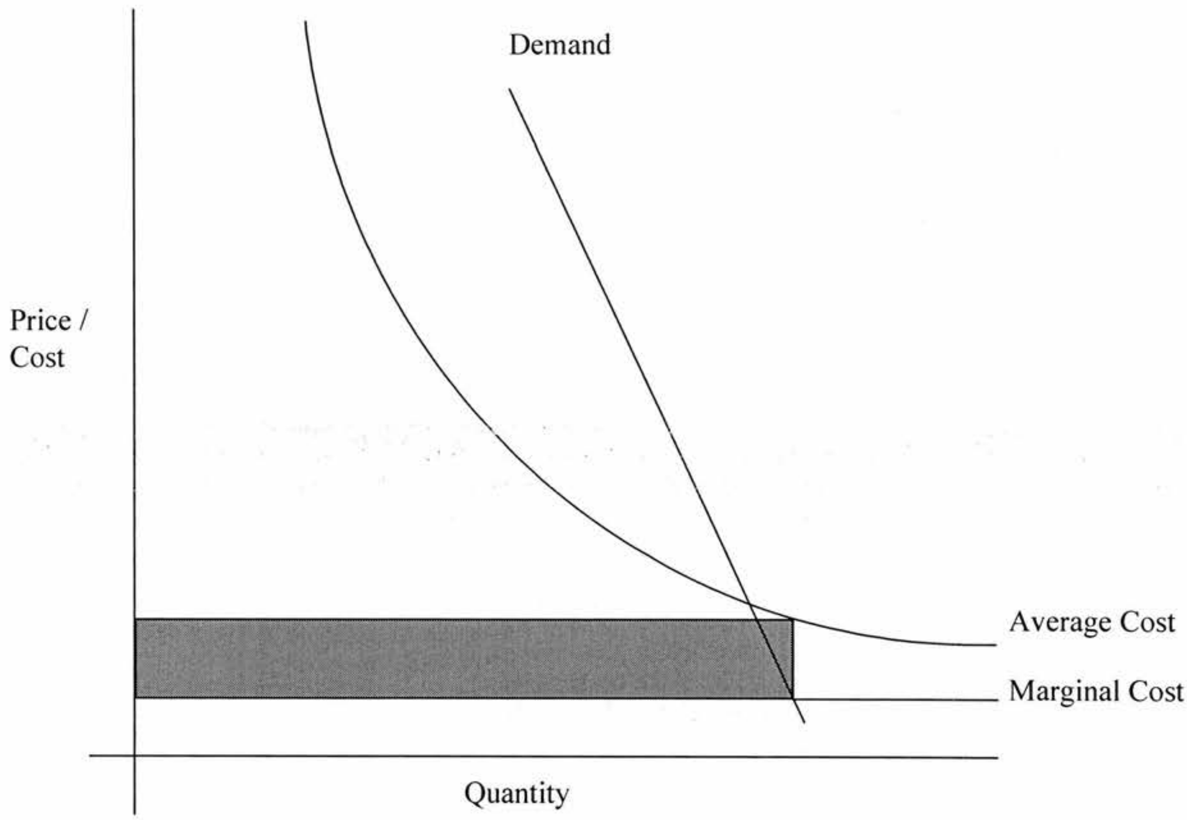
4.2 METERING AND PUBLIC UTILITY REGULATION

Like any integrated system, utility networks require to be built to cater for the peak demand. It follows that during times of slack demand the system is running inefficiently. Moreover, the bigger the difference between the peak demand and the off-peak demand, the more inefficient the system. Differential pricing, where the price is more expensive during peak times and cheaper during off-peak times is generally seen as the best way of overcoming this problem. However, this requires the metering mechanism to have some form of timeclock to measure cheap and expensive periods. This technology, while ubiquitous in telecommunications, is rare in electricity and non-existent in gas and water. As a consequence of the difficulty of allocating costs in this stochastic system a traditional average-cost approach has several defects when deriving utility prices. Since the demand and time, as well as volume, are crucial factors in the cost of supplying utility products, there is no scope for average-costs to reflect this. It is evident that such allocation of costs on an average basis involves valued approximations and the neglect of the incentive effects for customers to consume efficiently. This has resulted in the widespread use of marginal-cost pricing in utilities

(Turvey & Anderson, 1977 and Littlechild, 1979).

Energy Utilities (1995) explains how the concept of marginal-cost pricing is particularly relevant to the debate on the most efficient pricing system for utility networks. Since these are often 'natural monopolies', where duplication of all, or part of the network, is not economically viable. A 'natural monopoly' is subject to increasing returns to scale where average costs decrease with increasing size - a doubling of output requires less than a doubling of inputs. Under these circumstances, marginal cost pricing has the implication that the company will make losses, as average costs are greater then the marginal cost. This is illustrated in figure 4 below. The shaded area shows the size of the firm's losses.

Figure 4: Marginal Costs Under Increasing Returns to Scale



Source: *Energy Utilities* (1995)

Marginal-cost and average-cost pricing are not the only principles that can be used. There are numerous other alternatives, most notably *Ramsey Pricing*, which has been advocated as possible ways to recover the fixed costs of providing the network (Baumol *et al.* 1977 and *Utility Finance*, 1996: p.23). *Ramsey Pricing* calculates the mark-up according to the inverse of the price-elasticity of demand for each group of customers and products. In this way customers with a demand which is relatively insensitive to price, pay a higher mark-up.

Soishansi (1991) describes that in response to the peak demand issue there is a growing development of meters with 'time-of-use' (TOU) capabilities. Another more fundamental approach is to develop a new generation of 'solid-state' meters with no mechanical moving parts and with additional capabilities such as marginal cost pricing, data-collection and retrieval. Soishansi adds that the transition from electro-mechanical meters, to electro-mechanical meters with electronic features and then to 'solid state' meters is a significant one, not so much in cost, but in terms of the added functions and capabilities of the meters. Also Soishansi suggests that a modern well designed, 'solid state' meter is essentially a small computer with software-definable capabilities that can be reprogramed. This increased versatility and capabilities of more sophisticated hardware allows the utility companies to offer additional services. The prospect of new facilities of gas, water and electricity supply are now beginning to be realised, where separate public utilities can combine their metering services. The information technology industry also sees a potential of using metering facilities as a route into every household (Ofgas, 1997). This in turn will bring the possibility of combining public utility services with multimedia and home banking.

Advances in metering technology however, are calling into question whether some areas of public utilities are indeed 'natural monopolies'. Moreover if this is the case, the market would be able to define prices rather than the traditional methods of public utility pricing (Beesley & Littlechild, 1992). Soishansi (1991) explains that sophisticated metering coupled with improved communication facilities, allow utility companies to better manage and control their customers' consumption. Some customers, particularly large industrial customers, and residential customers with large loads should benefit from more sophisticated pricing schemes; and in turn utility companies would greatly benefit from their active participation in such schemes. With 'real-time' pricing (RTP) Soishansi argues that prices could vary from half hour to half hour, usually with some advanced notice. The advantage of RTP is that the utility can inform customers of pending high prices, whether they are caused by external factors, such as unusual weather conditions or high winter demand, or internal factors, such as availability or unavailability of inexpensive energy sources. By doing so, these customers who have the ability and inclination to modify their energy consumption can reduce the utilities' operating costs.

Even more significantly, 'real-time' pricing through sophisticated metering allows a spot market to be created where commodities such as electricity and gas can be traded on an open market (Henney, 1994; O'Neill, 1996 and Surrey, 1996). This in turn questions the integrated and natural monopoly nature of public utilities. The principle of separating the monopoly portions of utility from the potentially competitive ones, is known as 'unbundling'. This involves separating out the production and supply functions (which are potentially competitive) from the transportation functions (monopolistic). This principle is now widely used in the gas, electricity and telecommunications industry where a service provider pays a *Third Party Access* charge to the distributor.

However Soishansi (1991) explains that there is a rub; the energy company must now have the capability to communicate with a large number of customers, spread over a wide geographical area in 'real-time', or close to it. And the utility's meter must be capable of switching from one price to another. This is fine for the telecommunications industry but is more problematic for the energy and water utilities. The simple, stand-alone mechanical meter or an unread meter with a clock and two or three registers will no longer suffice. The meter must have up to forty-eight registers (one for each half-hour) and should be capable of keeping track of time accurately. In addition, the company should have the facilities to update the prices daily and inform the customers in advance if it expects to modify their load. To implement RTP on a large scale, the company must not only upgrade its metering apparatus, but must also install a communications network to get the pricing information to customers in near 'real-time'. Current RTP experiments depend on a variety of communication media to get the price information to tens of thousands of customers expeditiously, reliably, and inexpensively. Current RTP experiments rely on dedicated phone lines, microwaves and electricity mains-borne carriers. There are however inherent conflicting requirements, for example, fast, reliable and error-free communications systems tend to be expensive.

These views of pricing, in general, hold efficiency paramount in defining the net social worth of a particular policy. This net social worth is traditionally defined as the sum of consumers' and producers' surpluses, generated from the policy in question. Another approach termed the 'new institutional' approach to public utility problems, places less emphasis on efficiency maximisation.

According to Zajac (1978 and 1982), efficiency objectives are not the sole focus of price regulation. He contends that the regulation of a 'natural monopoly' is principally concerned with equity rather than efficiency. Williamson (1966) for example, has argued that macroeconomic instruments, like subsidies and taxes, are more effective in bringing about distributive justice than microeconomic policy instruments such as public utility prices. In explaining the nature of economic justice (Okun, 1975) developed the concept of 'economic' rights, similar to civil rights. Typically however, economic rights, like public education, use up more resources than civil rights but have similar public good characteristics to civil rights. Because of this, Okun argues that basic economic rights should be kept out of the market, the market having the role of promoting efficient allocation after basic needs (and rights) have been taken care of.

The new institutional economics was formalised by Williamson (1975) and examines issues such as legal control, contracting and co-operation. Ronald Coase (1937) pioneered the development of an analytical framework for transactions costs, which was a crucial antecedent to the new institutional economics. Coase examined the issue of whether a given set of transactions would be best performed with a single organisation (a firm) or by several economic agents interacting through the market. The new institutional economics also draws on von Hayek's (1945) institutional analysis of markets as well as the literature addressing the ineffectiveness of markets due to; risk (Arrow, 1971), public goods (Samuelson, 1954), information symmetries (Akerlof, 1970), and the contractual approach to the theory of the firm (Alchain & Demsetz, 1972). These foundations were synthesised by Williamson (1975 and 1979) into the transactional cost framework for comparative institutional design, which has become the bulwark of the new institutional economics. Central to Williamson's analysis are the notions of bounded rationality and opportunities. Bounded rationality originated with Simon (1962), who used the concept to refer to human behaviour which is 'intendedly rational but only limitedly so'. In other words, there are definite limits on the ability of the human mind to process information and to reason logically. These are seen as a constraint on decision-makers. In small numbers and in situations where information asymmetries exist (one party has information not available to the other party) the first party has an incentive to behave opportunistically. Opportunism refers to self-interest "seeking with guile" (Williamson 1975, p.26). As a result, information may be impacted, i.e. not made available completely to the second party. These problems may be overcome through markets when a large-number of interactions is possible. In other contexts, a hierarchy (e.g. a firm) may be the more efficient institution to mediate the transactions question.

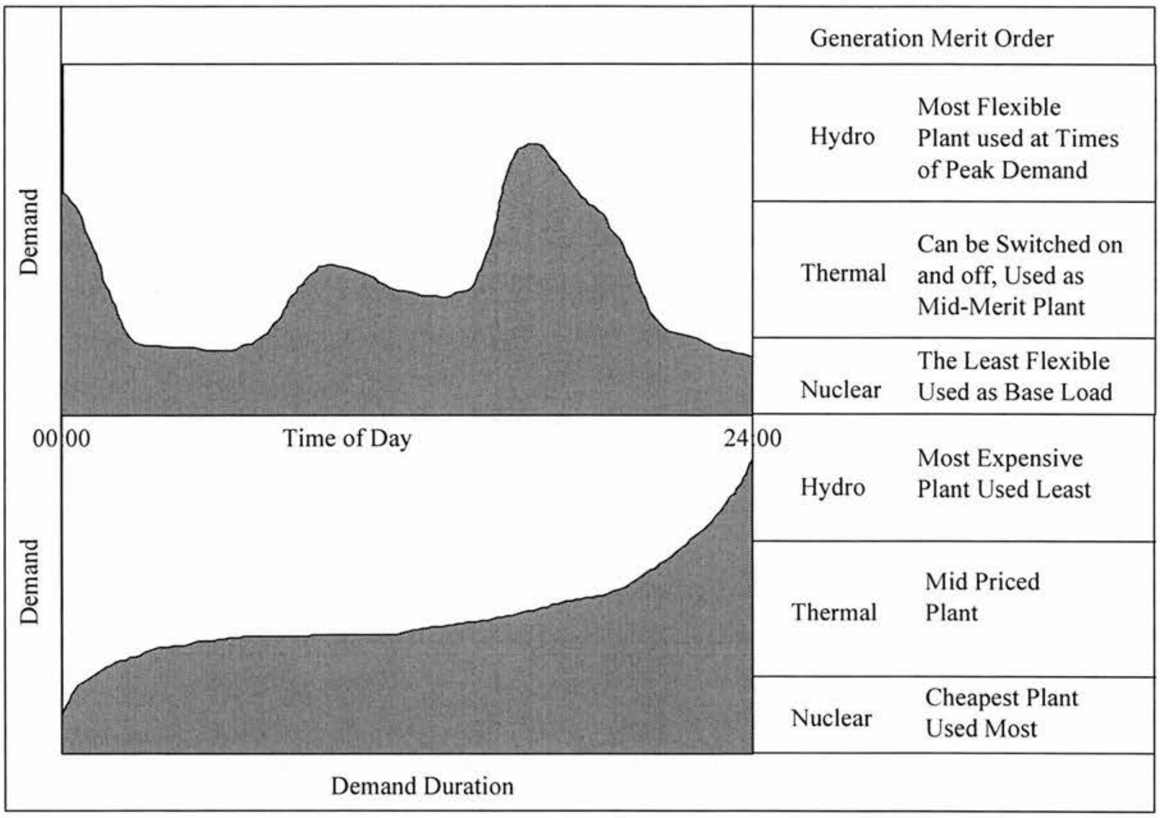
It is precisely this question of efficient institutional design (e.g. markets versus hierarchies) which has become the central issue in the new institutional economics. This issue is normally referred to as the comparative analysis of governance structures, where a governance structure is simply the institutional framework in which transactions take place. An efficient governance structure would be one that economises on bounded rationality and attenuates opportunism. Hierarchical governance rather than market governance will be preferred when contracting or frequent recontracting is not feasible, and where divergent expectations, small numbers and the potential for opportunism exist.

4.3 REGULATING ENERGY, WATER AND TELECOMMUNICATION INDUSTRIES

4.3.1 Electricity

To produce electricity in a form that is usable by the consumer requires four basic processes: generation, transmission, distribution and supply (Turvey & Anderson, 1977 and Crew & Kleindorfer, 1986). Generation is the process of converting other forms of energy into electricity. It is usually performed by power stations on a very large scale relative to the usage of individual customers. This large scale means that generation occurs in a centralised fashion, normally a considerable distance from the consumer necessitating the other two processes of transmission and distribution. Transmission consists of sending the electricity generated at power stations through wires on high voltage lines to substations. At the substation it is transformed down ready for distribution through low voltage lines to individual meters (customers). Supply consists of the costs that are incurred in metering and administration such as billing and customer service. The ownership of the four elements of the supply chain for electricity can vary considerably from complete vertical integration to separate ownership at each linkage in the chain.

Figure 5: A Stylised Load Profile and Load Duration Curve Showing Variation in Electricity Demand and Increasing Merit Order of Electricity Generation



Source: Turvey & Anderson (1977: p.288)

Along with the large transmission and distribution infrastructure, the key constraint of the electricity supply chain outlined by Turvey & Anderson (1977) and Crew & Kleindorfer (1986) is that electricity must be consumed as soon as it is generated. Storage is expensive and is limited to batteries (on a small scale) and specialised hydro-electric schemes (pumped storage). The aim of the electricity network they claim is to generate, transmit and distribute a given quantity of electricity at a minimum cost. To meet demand at any moment at minimum cost requires that plant to be operated in ascending order of running costs. Thus as demand increases, plants of higher and higher running costs for are brought into operation.[2] Above this short run analysis underlies long term decisions like the nature of the plant type to be installed for the replacement of existing plants or to extend the system. Such problems are solved typically by engineers and are known as system planners. System planning is a problem in dynamic analysis, for demand may be growing over time, technology may be changing, and relative fuel costs may be changing. Figure 5 shows a stylised load profile and load duration curve, illustrating how more costly (and flexible) forms of generation are required as demand increases.

Turvey & Anderson (1977) explain that pricing and metering has evolved in electricity to reflect the demand constraints on the generation as well as the transmission and distribution constraints in the system. The aim of this is to flatten the load curve in order to optimise the load profile. This has entailed separating costs into three categories: customer-related; unit-related; and demand-related charges. Turvey & Anderson go on to outline that customer-related costs are those costs that are incurred no matter how large or how small the number of units consumed, for example billing, collection, connection and consumer service. They describe how two-part and block tariffs would normally recover these costs in the fixed-charge of the first block of the tariff. Unit-related costs are those which vary directly with the number of units used. Such costs are mainly fuel, but a small part of distribution costs, and certain other work costs of generation and transmission. Demand-related costs are capacity related costs for generation, transmission and distribution and vary with the speed and time with which users consume electricity. Having divided up costs into these three categories, the rate analyst then divides the consumers into classes, the aim being that each class of consumer pays the total cost of supplying it, as defined in terms of the above categories. The idea behind this is an attempt to be fair to consumers as a class.

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[2] This can include: coal, oil, gas, nuclear, hydro-electric, solar, wind, tidal, geothermal power etc.

4.3.2 Gas

The gas industry covers activities in the production, transmission, storage and distribution of gaseous fuels (Peebles, 1992 and Crew & Kleindorfer, 1986). The gaseous fuels include natural gases, gases manufactured from coal (methane) and liquefied petroleum gasses or LPG (butane and propane). Depending on the nature of the gases and the economic and geographical circumstances, transmission and distribution call for either pipelines or transportation in pressurised tanks. This thesis only considers the natural gas (methane) industry that is delivered either by pipeline or in tanker form as cryogenic liquefied natural gas (LNG).

Crew & Kleindorfer explain that the natural gas industry possesses most of the features of 'natural monopolies' such as large transaction-specific investments, low variable costs, and scale economies. Although there is variation in demand, both seasonally and daily, peak demand is less of an issue than in electricity. Gas can be stored in gasometers adjacent to the network, underground in the cavities of porous rock formations and in high pressure pipelines (line packing). This means that 'time-of-use' pricing regimes are less widespread in the gas industry than in electricity and as a consequence complex metering is less widespread. Most gas pipeline companies buy their gas directly from producers, with only a small proportion of their gas coming from their own production subsidiaries. Thus the pipelines buy the gas from the gas producers and then resell it to customers, most of whom are unaffiliated distribution companies. The pipeline function is in the business of selling, storage and transportation services, although recently the issue has arisen as to whether it should take on common carrier status, which would require that it transports gas owned by others (*Third Party Access*).

4.3.3 Telecommunications

Unlike gas and electricity, telecommunications has no production function. It consists of the transportation of electronic information either in analogue or digital form through a fixed medium (e.g. copper wire over optic fibre or a mobile medium such as radio waves). This requires an extensive integrated transportation network, which up until recent years has been viewed as a 'natural monopoly' (Harper, 1989 and Headrick, 1991). Harper also shows that the considerable development of information technology over the past twenty years has increased demand and the competing communications media has called into question the 'natural monopoly' status of this industry. Mansell (1993) in her analysis of the new telecommunications market, suggests that instead of an 'idealistic' competitive market developing where a large number of communications companies are competing with each other a 'strategic' market is emerging. This 'strategic' market is being dominated by national and increasingly multi-national companies. As this market develops, Mansell suggests that new forms of innovative regulation are required to maintain the principles of 'public service'.

An 'added value' service provider network is also blossoming (Haddon, 1997). Third parties are increasingly using the telecommunications to not only use the network for telephony but also for telematics, video on demand and other multimedia services. One of these services is automated energy and water utility meter reading. Thus the functionality of the utility meter is increasingly coming within the realm of the information and communications industry rather than the energy and water industry.

Littlechild (1979) describes that metering telephony itself is carried out centrally on telephone exchanges and not at the customers' premises. Harper (1989) explains that this is now a highly automated process. The metering data is collected via electronic data collectors from the telephone exchanges and in turn transferred electronically to the billing systems. As such, it is fundamentally different to the energy and water utilities. The metering arrangements in the past were largely governed by technical considerations. Charges were imposed by meter pulses applied to the customer's meter by electro-mechanical equipment as the call proceeded. At the time of the call the equipment simply recorded its duration and destination. This information was processed separately later, to calculate the monetary charge of the call. But on Stored Programmed Control (SPC) these costs do not arise.[3] As SPC systems are introduced such charging systems have superseded electro-mechanical periodic metering where this had been used. There is thus now no technical constraint equivalent to the speed of periodic meter pulsing. This means that on telephony metering systems the cost of all the calls can be very closely tailored to their duration by using short charging intervals with a low monetary value per unit (Harper, 1989: ch.6).

4.3.4 Water

Unlike telecommunications, electricity and gas, where the industry is dominated by large companies, water is often supplied by many small companies (Lee, 1969 and Crew & Kleindorfer, 1986). This is mainly due to the physical and technical constraints in supplying water. Lee and Crew & Kleindorfer, explain that the technology of water supply involves collecting water in a reservoir, either above or below ground, transporting it to the purification plant, and then distributing it to customers. Thus, like electricity and gas supply, a water utility has four functions of production, transmission, distribution and supply. It also has one additional important function, that is, wastewater disposal and treatment. Most companies are defined by geographical constraints this usually being a natural river drainage basin. The management of water can be further complicated when the drainage basin covers differing political entities. This becomes significant in the supply of water on the European Continent where

[3] SPC is a technique under which exchange switching, routing and facility operations are controlled by computer software allowing computerised billing.

rivers such as the Danube and the Rhine run through different countries. Water supply can also be important politically within countries particularly when the administration of water rights is devolved, as it is in many countries to Local Government.

The second major factor in the management and regulation of water supply and its disposal is the environment (Kinnersley, 1994). In view of the fact that water companies are supplying drinking water it is not surprising that the water industry is subject to environmental regulation. It is important that customers should receive wholesome water that is free of bacterial and other contaminants. Indeed, one of the reasons for the development of an integrated water and sewage service was to combat diseases such as cholera and typhoid in the developing industrial conurbations of the mid-nineteenth century.

Water is also used for leisure and sporting activities. Kinnersley suggests that there is a balance between the amount that can be extracted for supply and what must be maintained to satisfy the ecology of the countryside and the various interests of water sports enthusiasts. To account for this Kinnersley explains that there is usually an environmental regulator and non-governmental pressure groups who are concerned with particular issues. Water is also an important source to industry other than supply. It is a major mode of transport, particularly in large continental masses. The inherent potential energy within a watercourse can also be tapped to generate hydro-electric power. Crew & Kleindorfer highlight that hydro-electric power, together with large irrigation schemes can both have an enormous economic and environmental impact on a geographical region. These issues are only mentioned to highlight the enormous importance that external interests play in the water industry. This study however restricts itself to the supply of water through privately or publicly owned companies.

Both Kinnersley and Crew & Kleindorfer suggest that the nature of water supply suggests that it is very difficult to visualise water being traded in an 'unbundled' nature, like gas and electricity. Since there is usually little interconnection between discrete distribution networks, competition in the water industry is not practicable. For the same reason, competition in supply and sewerage disposal is unlikely although supply and sewerage may be done by separate companies. With the absence of any possibility of a competitive market, water is the most monopolistic in nature of the public utilities.

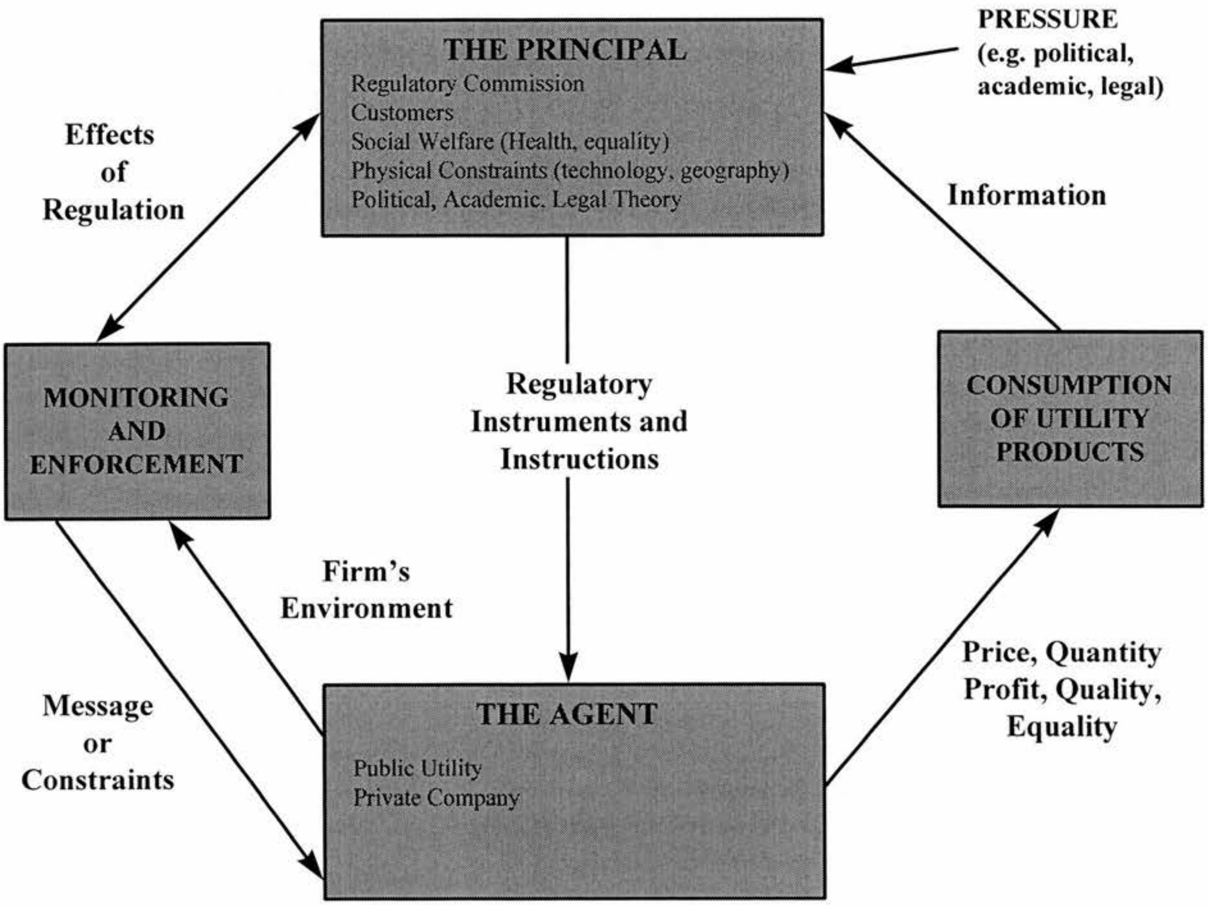
As with the other utilities metering is crucial in the management of water. Lee (1969) explains that the costs of distribution are highly dependent on the distance from the treatment plant. In addition to the capital costs of providing transmission, there are the costs of maintaining the pipes and mains, and the additional costs of pumping. So each litre delivered to a distant location has an additional pumping cost compared to the costs at a closer location. Another concern about pricing arises from the stochastic nature of demand and supply of water. For example dry weather means not only that supply is down but also that demand increases for sprinkling and crop irrigation. One solution to the problem, would require that the pricing policy be allowed to vary according to weather conditions.

4.4 METHODS OF PUBLIC UTILITY REGULATION

4.4.1 The *Principal-Agent* Model

The simplest way of describing the regulatory process in public utilities is through the *Principal-Agent* model which is sometimes called the REGULASY (*regulation under asymmetric information*) model (Bös, 1998). This is where the consumers and the regulatory commission are seen as the *Principal*, and the utility is the *Agent*. This is depicted in figure 6 where the *Principal* is the regulatory commission representing the consumers.

Figure 6: The *Principal-Agent* Model of Regulation



Source: Crew & Kleindorfer (1986: p.110)

The regulatory commission attempts to achieve the desired quality of public utility services (right hand box) by a number of regulatory instruments (vertical arrow) like rate-of-return and price regulation, moral persuasion, threats and appeals to the public through the media. The public utility responds to these signals according to its motivation (e.g. whether or not it aims to maximise profit) with a set of behavioural rules and a resulting control of prices, quantities, quality and profit. The commission attempts to see what effect its instruments are having on the public utility by monitoring and enforcement. The effect of this is that these get changed as they move through the monitoring and enforcement arrangements (see box and arrows on left). Information on prices etc., also comes back directly (on the right hand side of the diagram) from the vector depicting the consumption of utility products. In addition there is exogenous pressure at work, shown in the top right hand corner. This can come from a number of sources. For example, a regulatory commission might find itself under pressure from the State Government.

Crew & Kleindorfer (1986) explain that there are five types of regulation: public operation and ownership; profit regulation; price control regulation; franchising; and deregulation. These will be outlined in the following sections.

4.4.2 Public Operation and Ownership

Public operation and ownership as a solution to the natural monopoly problem is in widespread use (Littlechild, 1979; Lucas, 1979; Harper, 1989 and Henney, 1994). Henney suggests that the basic idea is very simple. The Government owns and manages the utility instead of it being in private hands. At first sight, the public enterprise has several advantages. The cost savings arising from a natural monopoly are automatically retained by society as a whole rather than being retained by the monopolist. Even if the public enterprise charged pure monopoly prices, the monopoly profits would be retained by the Government, the public enterprise being just another tax collector. The allocative inefficiency would continue, as taxes are a source of inefficiency anyway. However, pure monopoly behaviour is rarely advocated by the supporters of public enterprise. Rather public enterprise is typically envisaged as having the potential for maximising welfare. However, it does not always work out that way. Prosser (1986) sums up much of the frustration caused by this sort of regulation in the UK in the nineteen-seventies:

"The amount of consideration given by ministers and civil servants, and even parliament, to the consumer in the nationalised legislation was much less than given to the position of the workers and trade unions, and very much less than that given to such general aspects as compensation and the role of ministers...Undoubtedly it never entered the heads of many Ministers and their supporters that consumers might be in need of protection from the Boards of these industries."

4.4.3 Profit Regulation

The United States approach to controlling monopolies that provide a public service, it is clamed by Crew & Kleindorfer (1986), is founded on greater confidence in capitalism and less on public ownership. They describe how a privately owned utility is coupled with a regulatory framework of Federal and State public service commissions. Over time, a philosophy of public interest has developed, to the effect that there is a social contract between the public and the utility. In this 'contract' the utility provides the service the public wants (as interpreted by a commission) in return for being paid a reasonable return on the capital employed in the business. The approach, called 'rate-of-return regulation', effectively allows a utility to set its tariffs on a 'cost plus' basis. The disadvantage of 'rate of return' regulation' is that there is an incentive to inflate their asset base unduly and that it gives no direct incentive for companies to reduce costs (Henney, 1994).

4.4.4 Price Control Regulation

Instead of regulating the profits of utilities an alternative is to regulate prices, known as 'RPI-X' (Henney, 1994). The concept is that regulated prices charged by the industry should normally rise less rapidly than prices in general (RPI), by the amount that reflects the efficiency improvements deemed achievable within the technical and economic conditions of the industry (and reflected in the size of the 'X' term). Henney (1994) suggests that price control has a number of advantages: It is transparent and easily comprehensible; it minimises information requirements; and it theoretically does not require knowledge of a utility's asset values. It also allows companies to retain the benefit of any efficiency gains greater than the implied 'X' term, and thus gives more incentive for efficiency. However, the advantages of price-based controls are in reality not so clear-cut. For example, companies may have an incentive to conceal or postpone price-cutting indicative prior to the setting of the control. In addition, price controls do, in practice, have significant information requirements in order to set an appropriate value of 'X'. Furthermore the regulator needs to take a view of appropriate rates of return of the industry regulated.

4.4.5 Franchise Bidding

Demestez (1968) proposes franchise bidding as a means of dealing with monopoly problems. The basic idea is to periodically publicly auction off the right to run the monopoly as a protected franchise. Bidders would be required to specify, say for the next period of five years, the prices they would charge for the monopoly's products. If another bidder could operate the monopoly more efficiently than the present franchisee, the incumbent would be required to turn over the ownership of the franchise to the winning bidder. The bidder would be compensated for the transaction-specific assets by the winning bidder. An alternative to a complete contract is an incomplete long-term contract. Here adjustments would be permitted for unanticipated developments. However, as this opens the door for opportunistic behaviour, penalty clauses may be included as part of the contract. Another possibility, which is used frequently in union contracts, is arbitration as a means of dealing with events unforeseen by the contract.

4.4.6 Deregulation

The argument for deregulation rests on the notion that the gains from scale economies and price control are small in relation to the inefficiencies of regulation. Perhaps the strongest statement of the deregulation approach was originated by Posner (1969, p.634):

"The logical and empirical foundations of common carrier and public utility regulation are too shaky to support further extensions ... Non-extension offers the most substantial prospect for the eventual elimination of regulation ... (because) in the long run, there may be few natural monopolies, perhaps none, such is the change in consumer taste and technology in a dynamic economy."

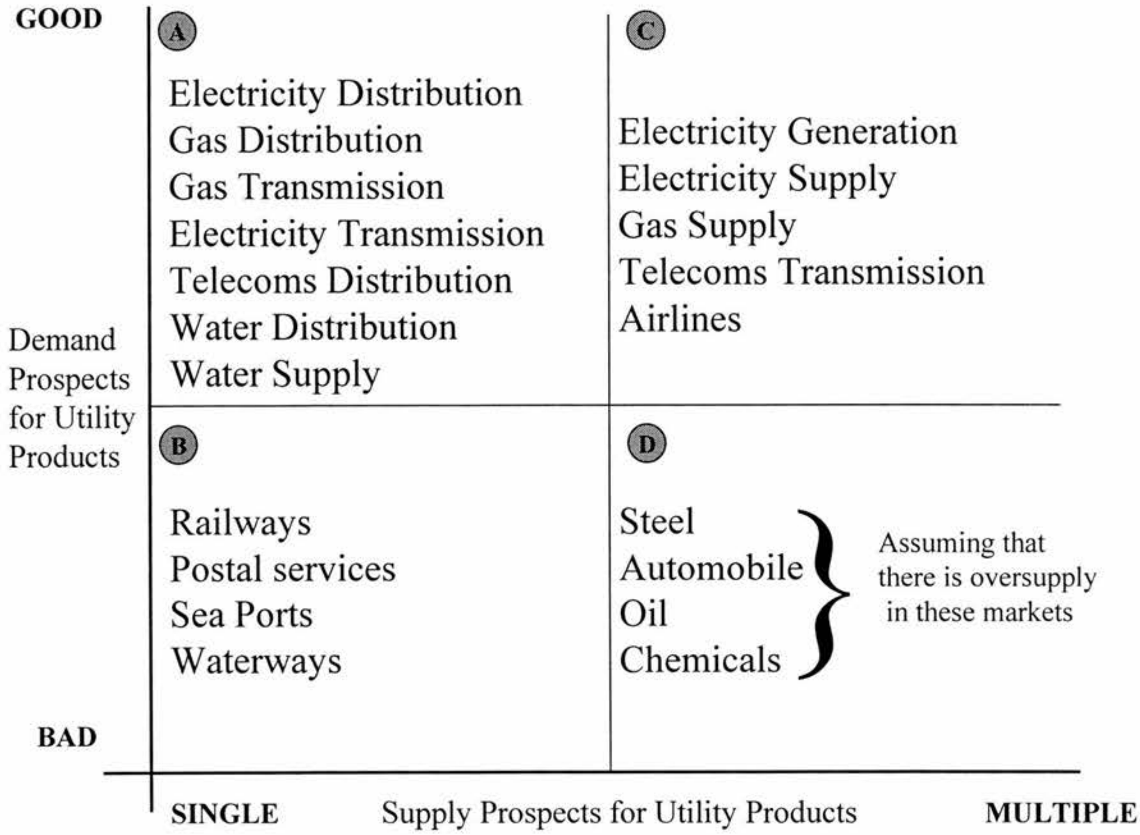
A number of deregulatory alternatives are possible including; unregulated monopoly, self-regulation and 'pseudo-competition'. Unregulated monopoly involves getting rid of the price regulatory apparatus in existence. In the case of utilities this would involve the abolition of the regulatory commissions, although some regulation of safety, service standards and environment might continue. Along with this would go the abolition of industry's exclusive franchises. There would be no legal prohibition against entry. There would be absolutely nothing legally to prevent two or more utilities supplying the same geographical area. According to the contestable market hypothesis of Baumol *et al.* (1982), when there are no sunk costs there would be no need for two firms actually to compete, merely the threat of entry would discourage the monopolist from raising his price above the cost-covering level. This contestable market model, it is argued by Crew & Kleindorfer (1986), has little applicability to the 'natural monopoly' problem, since sunk costs are typically significant in the traditional monopoly sectors. Many 'professions', e.g. medical, dental, and legal, practise self-regulation with the State Governments providing assistance with licensing and enforcement. Regulation by the 'professions', however, usually involves professional practices. On the surface, utility regulation has little in common with professional self-regulation. However, Crew & Kleindorfer (1986) suggest that like the 'professions', the utilities are service orientated, and utilities may be able to design appropriate dispute resolution procedures that may be responsive to customer complaints, including presumably excessive or inappropriate rates. Moreover they argue that the potential for self-regulation would be increased if the State played an overseeing role. The companies should be aware that if the State deemed that inadequate due process was being given to customers, or that the self-regulators were not preventing monopoly exploitation, then the regulator could step in, fix rates and take other appropriate actions. The threat of this might place some discipline upon self-regulators. In pseudo-competition, competition and social regulation exist simultaneously. Crew & Kleindorfer (1986) point out that there are obvious problems that need to be considered when implementing this form of regulation. Splitting up an organisation will involve sacrificing economies of scale and scope. The transfer of ownership from Government to a few number of shareholders may merely transfer the administration from political abuse to the abuse of individual capitalists. There will be a temptation of regulatory capture to either a particular pressure group, whether it be customer, shareholder or philosophical ideology.

It is clear that a nationalised industry should be deregulated if the net benefit to society is positive. Some indication in clarifying these issues can be found in Beesley and Littlechild's *Principles, Problems and Priorities in Deregulation* that is displayed in a simple 2x2 matrix shown in figure 7 (Beesley & Littlechild 1992). Demand prospects for utility products are termed as 'Good' or 'Bad', depending on long-term trends, and supply prospects are classed as conductive to 'Single' or 'Multiple' (competing ownership) depending on the developments of technology.

In Quadrant D, industries present no problems of monopoly power, since multiple ownership is quite feasible (within the UK at least). As a result of a large amount of competition from abroad, these industries are unlikely to survive in their present state and must adapt to competition. Consumers will gain indirectly, notably as taxpayers but also through the greater choice of competitive products.

Industries in Quadrant C are characterised by good long-term prospects and at present have no significant problems of monopoly power, because multiple ownership is viable. Beesley and Littlechild (1992: pp.30-37) suggest that these are prime candidates for deregulation.

Figure 7: Beesley and Littlechild's 2 X 2 Matrix



Source: Beesley and Littlechild (1992: p.32)

Industries in Quadrant A are characterised by good demand prospects, but the supply prospects do not favour multiple competing ownership. Local distribution systems for electricity, gas and telephones are characterised by high sunk costs. With the possible exception of telephones they do not face much technological challenge, and will be sustainable as local monopolies. Consumers are therefore at risk.

Industries in Quadrant B have declining demand prospects while their supply conditions favour a single organisation. Nationalisation was seen as a means of resisting decline: it led to continued injections of new capital and the financing of losses. Even after privatisation these industries would remain in Quadrant B. The aim of privatisation would be to facilitate the movement of resources out of these industries and/or use existing resources more fully by developing new products and services. However, social and political problems will accompany the withdrawal of services. Privatisation schemes will need to be designed with careful thought to non-commercial obligations.

Combining Beesley and Littlechild's analysis with the *Techno-Economic Paradigm* described in section 3.4 suggests that information technology has played a crucial role in deregulation. It has reduced the transactions costs and facilitated market trading within the industries appearing in Quadrant C. In effect there is another dimension to Beesley and Littlechild's matrix, that is technological innovation. It is the role that innovation has played in this deregulatory process which will be discussed in the following chapters of the thesis.

4.5 CONCLUSION

Metering is used in public utility regulation primarily as a metrological device in order to implement cost reflective pricing, but with innovations in information technology this role may be changing. This is crucial since in integrated networks the capital-intensive infrastructure is designed to cater for the maximum demand. The role of metering becomes even more important in industries where storage is difficult such as in electricity, or if there are concerns over the conservation of the commodity as there are in water. Due to the 'natural monopoly' characteristics of public utilities, they require to be regulated. This can take the form of public ownership and operation to complete deregulation. It is also suggested that if the utilities are unbundled into their component functions, different forms of regulation can be implemented in the production, transmission, distribution and supply functions. The role that information technology, and metering in particular, has played in this process is crucial. The next chapter will consider some approaches to the technological innovation, which will be used as a framework for the analysing of metering development, and provide insight into its effect on the regulatory process.

CHAPTER 5

TECHNOLOGY

5.1 INTRODUCTION

There are many different approaches to the treatment of technology in the academic literature. Technology may be approached through the traditional disciplines of economics (Stoneman, 1983 and Clark, 1985), sociology (MacKenzie & Wajcman, 1986 and Elliot, 1988) and philosophy (Polanyi, 1962). Another approach is to assume that there is a fairly stable and matter-of-fact state between the social, economic and/or the technical dimensions that can be quantitatively modelled (Stoneman, 1983 and Kaimien & Schwartz, 1982). A third assumes that the social, psychological and/or economic factors shape technical development (MacKenzie & Wajcman, 1986). It is also sometimes reciprocally assumed that technological innovations are also capable of shaping social, psychological and/or economic environment factors (Winner, 1977). Some studies, on the other hand consider technological innovation at the *micro* and *meso* scales within firms or organisations while others are concerned at the *macro* level of inter-sectoral infrastructures. A further approach, more in a philosophical vein, tries to tackle technology from its lexicographical and taxonomic definitions. Each approach provides valuable insights into technological phenomena and the innovative process in their own ways. Since the study of technology can be so diverse it is important to bound one's study to a manageable proportions. The approach that is adopted in this thesis is the role that technology plays in the regulation of public utilities. Thus it is the study of a business process on an inter-sectoral scale that is the focus of this thesis. In addition, chapters 3 and 4 have shown that the regulatory process in public utilities is multi-disciplinary. It is also this multi-disciplinary principle that shapes this chapter and in particular it is argued that the role that technological innovation plays in public utility regulation needs to call on many perspectives.

The chapter begins with a brief discussion of the major approaches to technological innovation and how they may be applied to public utility regulation. A more in-depth appraisal of some of the interdisciplinary approaches to innovation will then be presented. This will begin with a discussion of how *Systems Theory* can help to describe how artefacts within utilities are not self-contained but part of larger technological systems. Technological and system change will then be described using *Sociotechnical Constituencies*, *Techno-Economic Networks* and *Evolutionary Theory*.

5.2 TRADITIONAL WAYS OF ANALYSING OF TECHNOLOGY

5.2.1 Economic Models of Innovation

Ever since David Ricardo (1772-1823) discovered that the laws of supply and demand alone would lead inevitably to a 'stationary state' it has been recognised that there is some other force which can be called, and could be defined as, technology (Ekelund & Hebert, 1975: p.93). Over the years, economists have tried to incorporate technological phenomena in the innovative process. The most significant were Karl Marx's critique of the Capitalist State in *Capital* (1867) and Joseph Schumpeter's in *The Theory of Economic Development* (1934) and *Capitalism Socialism and Democracy* (1943). In *The Theory of Economic Development* (1934), Schumpeter sees that individual inventive 'entrepreneurs' working in competitive markets drive technological development. This assumed perfect competition and the definition of the 'entrepreneur' left no scope for large scale R&D. In *Capitalism Socialism and Democracy* (1943), Schumpeter stresses that corporate research and development is also a major source of industrial innovation, and large economies of scale particularly in the capital intensive sectors has led to most technological advances taking place in large monopolistic firms. The first attempt to quantify the role that technology played in growth was done in independent studies by Abramovitz (1956) and Solow (1957). Abramovitz found that after accounting for the efficiency (capital-labour ratio), there remained unexplained growth. The more recent attempts at describing the economics of technical change have moved from the macro-economic principles of Schumpeter to cover most disciplines within economics.

Economists are now moving away from using only the production function and neo-classical approaches as a means of considering the impact of technology on the economy (Clark, 1985), to analysing the development of technology itself. Also the traditional approach to technological discovery of innovation and diffusion as a linear process is giving way to a more interactive approach to technological development. The invention and innovation process has been quantified by Rosenberg (1976: ch.6) in his notions of the inducement and focusing of innovation. Indeed, several projects over the past forty years have demonstrated that the role of the research and development as well as the market infrastructure was crucial for competitive success. Project TRACES and project HINDSIGHT in the United States, Project SAPPHO in the United Kingdom and many similar studies showed the importance of external networks of scientific and technical research for efficient performance (Freeman, 1982). Other research has considered technology output measures. The methods of measuring the output of inventions and innovations have centred around three areas: patenting activity (Schmookler, 1966; Comanor & Scherer, 1969; Bosworth, 1980 and Soete, 1981); innovative activity (Mansfield, 1968; Freeman, 1982 and Stoneman, 1983: p.15); and outputs in terms of training and learning (Pavitt, 1993). Also many attempts have been made to show how it is possible to 'account' for technology by measuring input and output statistics (Clark, 1985: p.74). Other approaches have focused on developing the analysis of the nature of the time-path following the diffusion path of technology (Stoneman, 1983: p.69; David, 1975 and Davies, 1979). David further suggests that each firm may have a critical level of stimulus and will adopt an innovation only when the stimulus represented by the innovation itself exceeds a critical level. Davies argues that due to uncertainty, firms make decisions in a behavioural manner that can more appropriately be described as 'satisficing' (Simon 1962) than as 'profit maximising'.

This 'satisficing' may involve such factors as increasing returns, technical constraints, social obligations and strategy.

The economic analysis of the innovative process has also been split into three levels of scale by Stoneman (1983: p.67); intra-firm diffusion, inter-firm diffusion and inter-sector diffusion.

Within Intra-firm Diffusion Stoneman (1983: ch.6) considers two neo-classical approaches: the *Mansfield Model* predicts that the diffusion of technology will be a sigmoid curve and the *Bayesian Model* considers that firms learn in a Bayesian way from their experience. Within new institutional theories of the firm (see section 4.2), research centres around the concept of the supply of knowledge. It is also again founded on the concept of 'satisficing' rather than optimising behaviour (Simon, 1962), as well as Cyert & March's (1963) behavioural theory of the firm. The important role played within a firm by groups of conflicting interests and goals, introduces uncertainty into firms' operations, and opens up the 'black box' of the firm (Rosenberg, 1982). Williamson's transactions costs analysis (1975 and 1991), described in the previous chapter, has similar foundations. Also within the same conceptual framework Nelson & Winter propose *An Evolutionary Theory of Economic Change* (1982) (see also Winter, 1991: pp.186-189 and Nelson 1994: pp.21-32). It emphasises that technology and the structures of industry co-evolve. It is much concerned with how patterns and innovative routines and artefacts evolve and are reproduced through time in the face of selective pressures (see section 5.3.4 for further details).

Inter-firm diffusion splits into three camps. The *psychological approach* proposes that diffusion takes time because actors respond to stimuli. The *probit approach* proposes that 'across the population of potential adopters' the magnitude of at least one economic variant influencing the outcome of individual adoption decisions is not constant but instead, can be described by a more or less continuous frequency density function. The *game theoretic* approach meanwhile describes the adaptation of technology through a series of logical decisions in anticipation of competitor's actions.

The study of inter-sectoral technological innovation centres around two issues. Whether the monopolistic or competitive market structure is more conducive to innovation, or whether innovation is best left to individual entrepreneurs or large firms (Kaimien & Schwartz, 1982: pp.27-37). Intertwining with this debate about 'large vs. small' and 'monopoly vs. competition', is the argument whether technology develops through 'demand-pull' or 'technology-push'. 'Demand-pull' emphasises that innovation is spurred by the market operating amongst a lot of highly motivated individual entrepreneurs and is espoused by recent deregulatory polices in the UK (Harper, 1989; Kinnersley, 1994 and Offer, 1992). However, many writers, including Rosenberg (1982: p.231) suggest that a purely 'demand-pull' approach ignores the operation of a complex and diverse set of supply-side mechanisms that are continually altering the structure of production costs and are therefore fundamental to the explanation of the timing of the innovation process. Thus technology is now viewed as coupling technological opportunity and market demand. Also within this macro-economic sphere lies also the *Techno-Economic Paradigm* described in section 3.4. It suggests that growth and recession in the economy is dominated by different fundamental technologies. To be effective a nation requires those institutions to be compatible with that technology. Thus the *régime of régulation* suitable for an earlier set of fundamental technologies may be quite inappropriate for newer technology.

5.2.2 Sociological Analysis of Innovation

In sociology, attention has been paid to the role of technology since at least the nineteen-fifties. The first major feature of the treatment of technology in the sociology of organisations was the relationship between type and organisation structure. The pioneering work of Joan Woodward (1965) established the presence of a correlation between the type of technology used (for example mass, batch or flow) and the organisational structure adopted. The conclusions reached are, that certain technologies for the business or organisation, pre-dispose an organisation to favour certain structures and eschew others. Another pole in the argument is the 'strategic choice' paradigm associated with Child (1972) which retains a contingency flavour but uses contingencies to set limits on action, rather than to determine it. These early attempts in a certain way have paralleled what is happening in economics, but they have not dealt with the provenance of technologies, only their supposed effects.

A second feature of the sociological discussions of technology is the analysis of technology in relation to the organisation and the control of work. Again there have been two rather opposed traditions. First, there has been the socio-technical systems approach. Emery & Trist (1960 & 1965), focus on intra-firm activities in which the 'implementation' of new technology and its effect on work redesign and control were studied. The issues were seen here as task design and allocation, in order to optimise both efficient use of technology, and worker satisfaction. Looking at analysis outside the theories of the firm, Callon (1986) takes an *Actor-Network* approach in an attempt to find a neutral vocabulary to describe the actions of those who are involved in building *Techno-Economic Networks*. The idea is that actors build messy networks that combine technical, social, and economic elements. Callon and his collaborators stress that the elements (including entrepreneurs) who bind together in networks are, at the same time, constituted and shaped in those networks. This means that they avoid making assumptions a backdrop of social, economic, or technical factors: the backdrop is something that is itself built in the course of building a network. It also means that they avoid making the common-sense assumption that people, entrepreneurs, or machines are naturally occurring categories. How boundaries are drawn between (for instance) machines and people, thus become a subject in their own right. This notion has its roots in the discipline of semiotics, which is a rigorous vocabulary based on symbols for talking symmetrically, about people and machines (this concept is explored further in section 5.3.3). To a first approximation, *Actor-Network Theory* has much in common with Hughes' (1983) version of *Systems Theory*, which was developed in the studies of the history of technology. This was originally intended to describe, and account for, the growth of large technical systems. Hughes' argument is that the successful entrepreneurs were those who thought in system terms, not only about the technical character of their innovations but also about their social, political, and economic context. In effect, he says that entrepreneurs, like Thomas Edison, designed not only devices but also societies within which these devices might be successfully located (see section 5.3.1 for further details).

The second tradition has taken a more political approach focusing particularly on the labour process (Braverman, 1974; Cockburn, 1983 and Noble, 1986). Many of these accounts began from a Marxian perspective that emphasises that technological decisions follow from the effects of in-built biases in society. The implication of this approach for the provenance of technology is that objectives of exploitation are variously interpreted as valorisation, direct control of workers or gender repression, and are seen as ever-present influences on the process that generates technology. Winner (1977: pp.306-335), takes a slightly different approach and considers that technology itself may delimit and even determine human needs and wishes. In this he evokes the myth of Frankenstein, illustrating the possibility of humanity facing bondage to autonomous technology.

5.2.3 The Role of Knowledge in Innovation

Almost in parallel with the research traditions in the sociology of technology, in the nineteen-sixties began the development of the sociology of science (Barnes, 1972). This branch of research highlights the procedures and determinants of scientists' behaviour, and the limitations of so-called scientific method. In the sociology of science it has been argued that the rigorous scientific method grounded in logical empiricism is socially constructed. It then follows that science is open to many interpretations, which may depend prevailing on social trends. Accordingly, scientific knowledge (and now it is argued technologies and technical practices) are built in a process of social construction and negotiation, a process which is often seen as driven by the social interests of participants. Authors such as Collins (1981) use terms such as 'interpretative flexibility' and 'closure' to express how conflicting groups interpret the issues and impose a solution. At the same time there has been a blurring of the distinction between science and technology (Faulkner, 1994) based on empirical studies of the innovative process (Rothwell, 1977 and Freeman, 1982). This has encouraged researchers such as Pinch & Bijker (1990) and Molina (1996) to suggest similar techniques can be used to map technological development, as in the sociology of science (see section 5.3.2 for further discussion). Schot (1992), Rip (1995), Rip *et al.* (1995), Schot & Rip (1997), Deuten *et al.* (1997) and Rip & Kemp (1998), take this logic one step further by presenting mechanisms for the introduction of new technology at the societal level (see section 5.3.4).

5.2.4 Similarities between Approaches

The similarities between these accounts can now be briefly analysed. There has been a trend towards greater degree of realism, in that the dynamics of technological innovation and some tools used in the analysis have become more similar. For example, the concepts, from routines to paradigms, which have emerged in evolutionary economics and which describe patterns and stabilities in firms and technologies are common to all disciplines. *Systems Theory* and *Actor-Network Theory* act as counterweights to any technological, market or sociologically determinist interpretation of technology. There is a degree of commonality among these conceptual approaches, in that they all imply a degree of fine structure in the technological and organisational features of the world under study. This structure has a short to medium-term stability, but can eventually change by means of transitions to other states and structures. Put at its starkest, it has been suggested by Coombs *et al.* (1992) that where the evolutionary economist sees a stable natural trajectory, the sociologist sees a normalised irreversible *Techno-Economic Network*: where the evolutionary economist sees a radical innovation, the sociologist sees ruptured networks and the emergence of new networks. Also, the nature of knowledge in organisations has also become an important component of modern theories. Thus knowledge can be characterised as, for example, tacit or codified (Polanyi, 1962), public or private (Teece, 1987), local and cumulative (Pavitt, 1990). An important outcome of these considerations is that knowledge can be seen as constituents to larger phenomena such as technology. These phenomena may produce, to varying extents, specific irreversibility and path dependency that can be seen as the consequences of increasing returns to adoption of certain technologies (Dosi, 1982).

5.3 THE ANALYSIS OF INNOVATION AND TECHNOLOGICAL CHANGE

5.3.1 *Systems Theory*

The Seamless Web

It has become clear from chapter 4 that any form of technological innovation that occurs within public utilities can only be accounted for if it is seen within the context of the utility network as a whole. A version of *Systems Theory* (von Bertalanffy, 1971; Lilienfeld, 1978 and Emery, 1981), which deals with this, was developed in the history of technology by such writers as Thomas Hughes in *Networks of Power* (1983). In this book Hughes develops a number of sub-themes, for instance the nature of the innovative act is explored through the creativity of Thomas Edison and in particular the motivations, methods and sociological circumstances pertaining to his invention of an integrated electricity network. He introduces the notion of the 'reverse salient' or bottleneck within a system that provides an internal dynamic for technological evolution. He also compares the interaction of technology and politics by exploring the context of systems development in three Western cities: Chicago; London; and Berlin. Another theme brought out by Hughes is the theme of technology as an improver of natural circumstances. He cites the hydro-electric resources of the Sierras of California which were seen being transformed into economic goods by engineers and entrepreneurs. Another question that Hughes addresses is the autonomy of the technology. He concludes, like Winner (1977), that to some extent systems do have an internal drive, with the emergence of 'reverse salients' and their ongoing solution provides the engine for their evolution. Nonetheless, the style of different systems depends on cultural factors such as economic principles, legislative constraints, historical contingencies, and geographical factors, both human and natural. These *régimes of régulation* (my words) stem from the societies in which they grow, varying according to time and place. He suggests that in electricity networks one constant dominates and that is load factor (see section 4.3.1), and in many cases decisions are made to improve load factor, shaping the form of electricity supply systems. He also argues that if the management of public utilities relied solely on economic factors such as load factor, analysis would be relatively simple. But he argues that this is not the case. In London for instance, during the early part of the century, electricity utilities were contained within the boundaries of Local Government jurisdiction and thereby restricted to small-scale technology and limited diversity. This was the price that Londoners paid for placing high value on Local Government rather than low cost electricity. Also after the nineteen-thirties, electricity supply was used to supply social needs by subsidising rural and socially deprived communities through the notion of universal access at equal price. Thus he concludes that economics is not an absolute determinant of the growth of infrastructure systems. Power systems he argues, encompass a technical core of components as well as institutional components. He suggests that such encompassing systems could be labelled 'sociotechnical systems' rather than 'technological systems'. Unfortunately, Hughes ends his study in 1930, restricting his analysis to the growth of the electricity network infrastructure, and says little about the infrastructure change that has occurred since then. This thesis should be seen as building on Hughes' analysis by considering the changes in network infrastructures during the nineteen-eighties and nineteen-nineties. In particular, the role that information technology has played in Hughes' 'sociotechnical' process once a network infrastructure has become developed and established is studied. In order to do this, writings concerning innovation and change in the context of existing network infrastructures need to be considered.

The 'Highway'

Such an applied study of infrastructure change has been carried on an in the telecommunications sector of the USA. Saehney (1992) in his study of stages in infrastructure development of the public telephone network, describes it as the 'highway' of the information age (see also Kubicek & Dutton, 1997: pp.10-15). The advocates of investments in telecommunications infrastructure evoke the 'highway' analogy, to underscore the social and economic importance. Moreover Saehney has developed the 'highway' analogy to go beyond a relatively simple metaphor and has used it as a heuristic device for model construction. The experience with transportation technologies is used to develop an abstract model for understanding the growth pattern for emerging telecommunications technologies. Saehney argues that in the case of infrastructure technologies, the interconnections or the 'system of relationships' between elements are more important than the constituent elements themselves. This 'system of relationships' is greatly influenced by social, economic and cultural factors. Saehney argues that the extension of the telephone network into rural areas is a social decision, not a question of technological nodes (switches) and links (transmission channels). The actual placement of the network on the geographical space is therefore considered to be an artefact of social design rather than pure engineering considerations. In other words, the network structures of the infrastructure technologies grow in "the sociocultural milieu of the larger society." Thus, different societies are likely to influence the development of the infrastructure technologies in different ways. However, Saehney claims that within a socio-economic system the organising principles for the 'system of relationships' of different infrastructure technologies are likely to be the same. In the same vein Mansell (1993) demonstrates how both policies and technical aspects are themselves shaped by actors in the telecommunications sector, including Governments, public telecommunication operators, equipment manufacturers, and large users of public and private telecommunication networks. She goes on to consider the strategy of telecommunications policy which lies between an 'idealist' vision of full competition versus a 'structuralist' of dominant players being regulated by a creative public policy. Nonetheless unlike railways and telecommunications, many other network infrastructures have more than just a transportation component. The electricity industry has generation, the gas industry has upstream production and storage, and water supply involves storage as well as purification and waste-water treatment (see sections 4.3.1, 4.3.2 & 4.3.4). Therefore in these network infrastructures, the 'highway' model breaks down. Two possible ways forward are *Sociotechnical Constituencies* and *Techno-Economic Networks*.

5.3.2 *Sociotechnical Constituencies*

Alfonso Molina (1990; 1995 and 1996) builds on Hughes' notion that network infrastructures are sociotechnical systems, and attempts to order the system of relationships that Saehney recognises for infrastructure change in a formalised framework. He then presents a methodology to study the development of technology through constituency building and socio-technical alignment. His programme starts from the realisation that the process of innovation in technological development entails the build-up of *Sociotechnical Constituencies*. *Sociotechnical Constituencies* are defined as:

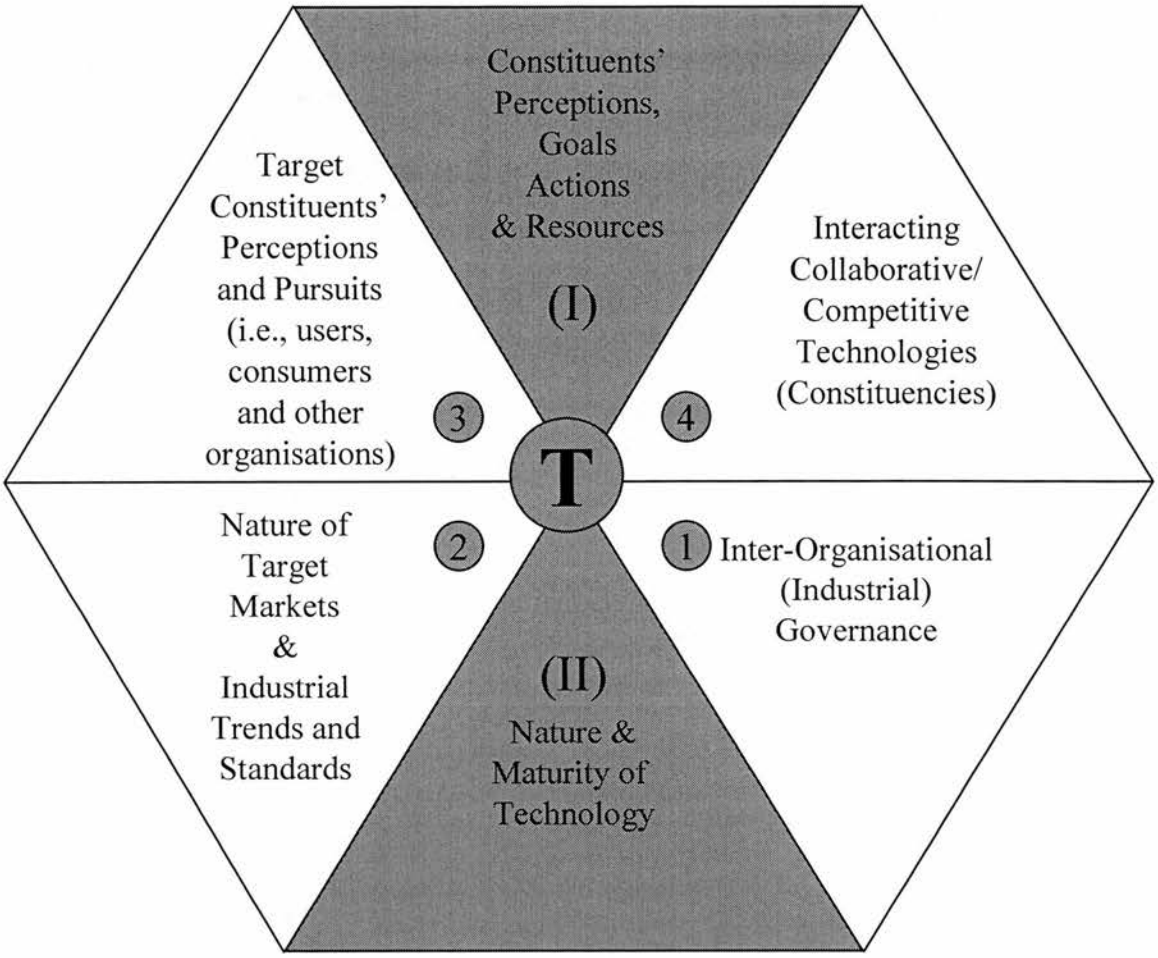
> "Dynamic ensembles of technical constituents (e.g. machines, instruments) and social constituents (e.g. institutions and interest groups) which interact and shape each other in the course of the creation, production and diffusion of specific technologies."

Molina's ideas are derived from works in the sociology of scientific knowledge, the increasing blurring of the science/technology distinction and developing interest in technology studies. Collins (1981) in his *Empirical Programme of Relativism* (EPOR) shows that during the development of knowledge there may be many ways of interpreting the same problem (interpretative flexibility) and when these possibilities are being closed down a closure occurs similar to Fleck's (1993) crystallisation of contingencies in the technical process. This theme of technological innovation is taken on by Pinch & Bijker (1990) who propose a format for the *Social Construction of Technology* (SCOT) where the notion of the social group can be given empirical reference in the study of technological development. The social groupings are then formalised into a *Sociotechnical Constituency* by Molina. These constituents are built up by an alignment, which is:

"The process of creation, adoption, accommodation (adaptation) and close or loose interaction (interrelation) of technical and social factors and actors which underlies the emergence of an identifiable constituency."

This process of alignment suggested by Molina may be both a constructive and destructive process, which involves situations of tensions and recommendations (termed interpretative flexibility) during the creation of a constituency. The constituency is congealed and finally crystallised and 'closed' in the form of the technological artefact. The concept of the 'diamond of alignment' has been used to illustrate the multiple dimensions of alignment required for successful constituency building at both the *meso* intra-organisational and *macro* inter-organisational contexts. Figure 8 shows the diamond of the inter-organisational (industry-level) alignment, which is the level of analysis being addressed in this study.

Figure 8: Diamond of Inter-Organisational Alignment



Source: Molina (1996)

The focus (centre) of the diamond is the evolving technology and its associated constituency. In the constituency there is no specific delineation between the constituencies, rather they should be seen as continually evolving. The shaded areas (I) and (II) represent the sociotechnical nature of the technology (T). The principle is that, the better the starting-off alignment of I and II (constituency/technology) with other various dimensions (1,2,3,4) of the 'diamond', the more effective the solution will be. Molina gives examples of inter-organisational governance (dimension 1), nature of target markets (dimension 2), outside parties that are target constituents (dimension 3), and interacting technologies (dimension 4).

Chapter 3 described how the regulatory process involves various *régimes of régulation* involving market, social and technical constraints. These are similar to dimensions 2, 3 & 4 in Molina's diamond which are bound together by *réglementation* (my word) or governing rules represented by Molina's dimension 1 in 'the diamond'. The constituency now turns into a regulatory framework in which the development of the technology can be studied.

Sociotechnical Constituencies provide a good and more comprehensive starting point in analysing the process of technical change within a network infrastructure than general *Systems Theory*. Indeed, section 15.3.2 of the thesis uses this methodology to analyse the influence if infrastructure architecture in metering. In order to obtain an insight into how technology has an impact in developing a network infrastructure, a mode of analysis that does not limit itself to the sociotechnical has to be considered. Such an analysis can use the notion of *Techno-Economic Networks*.

5.3.3 *Techno-Economic Networks*

Techno-Economic Networks (Callon, 1992a; 1992b and 1996) are derived from *Actor-Network Theory*, which grew up in science and technology studies as an attempt to understand the way that social and technical factors are embodied in texts and artefacts. It assumes that relations are explained through such phenomena as the 'seamless web' (Hughes, 1983) and 'heterogeneous engineers' or actors (e.g. entrepreneurs or scientists), the subtlety of which is partly linked to its derivation from semiotics. Thus there is a combination of an agency (actor) and a structure (network) which cannot exist without each other (Green *et al.* 1999). The distinction between objects and subjects (human and non-human) in *Actor-Network Theory* is not given but is rather made and remade, and it also describes how asymmetries are built up through extending networks of relations. This leads to a 'centre of translation' which defines the relationship between two actors which are inscribed in intermediaries such as texts and artefacts. A

Techno-Economic Network is a term to describe the types of organisations (research centres, commercial institutions, and public authorities) that result from Actor-Networks.

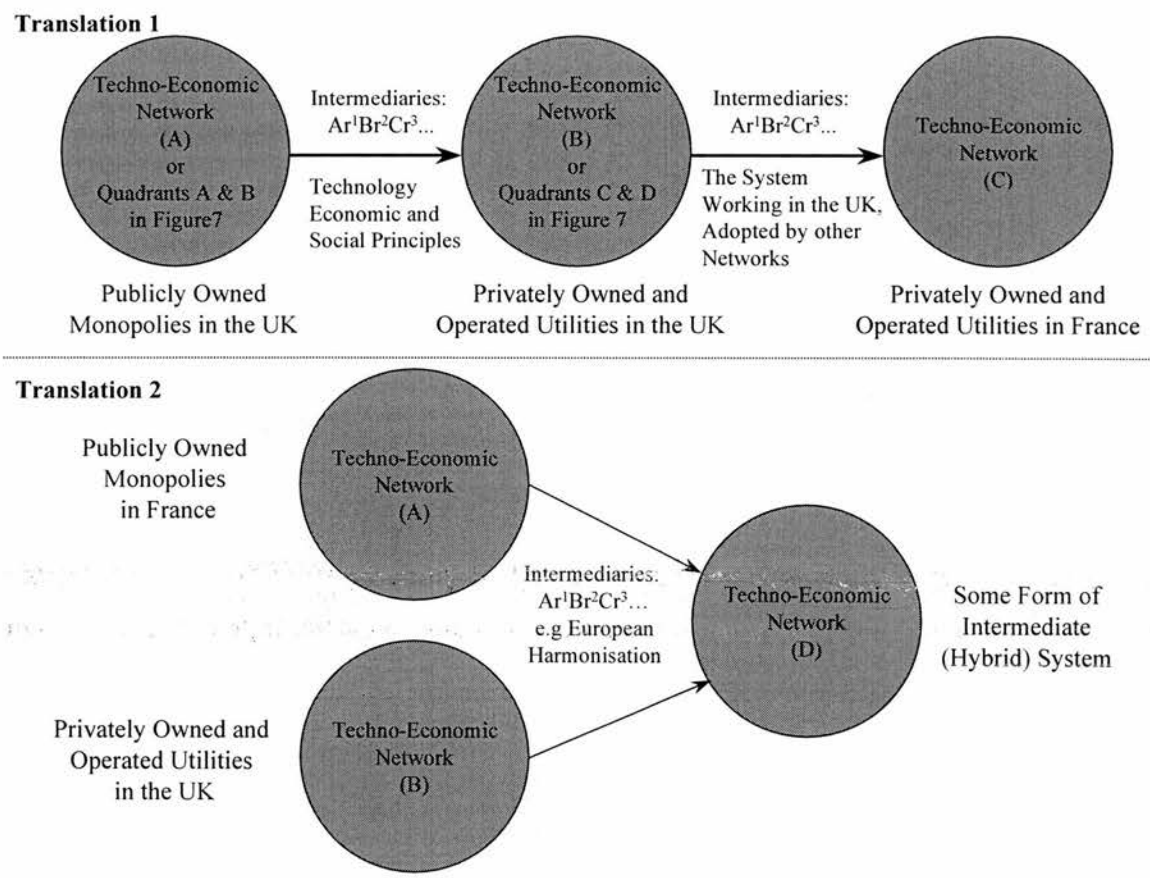
A *Techno-Economic Network* is defined as:

"A co-ordinated set of heterogeneous actors - for instance, public laboratories, centres of technical research, companies, financial organisations, users and the Government - who participate collectively in the conception, development, production and distribution or diffusion of procedures for producing goods and services, some of which give rise to market transactions." (Callon, 1992a)

In certain cases, Callon shows that it is possible to anticipate the evolution of these *Techno-Economic Networks*. The actors may behave predictably, and the technology and its products evolve along lines that are relatively easy to characterise. In other cases however, he suggests that the actors composing *Techno-Economic Networks* have significant degrees of freedom. They develop complicated strategies and there may be a number of innovations, and these may provoke unexpected rearrangements. They can separate into smaller networks, or they can join other *Techno-Economic Networks* to form more or less extensive ones.

The notion of *Techno-Economic Networks* has many similarities with *Sociotechnical Constituencies* in that they are both dealing with infrastructure systems, but they have also significant contrasts. The difference in the two approaches can be traced back to their philosophical foundations. *Sociotechnical Constituencies*, which is based on the sociology of scientific knowledge assumes that there is an intrinsic social element to all phenomena. On the other hand *Techno-Economic Networks* as in *Actor-Network Theory*, with its roots in semiotics, emphasises that symbols may be embedded in a natural non-human as well as a human process. Thus a *Techno-Economic Network* has a distinct advantage when considering the regulation of public utilities, since as Hughes (1983: p.463) points out; they are constrained by natural climatic and geographical factors. As well as the philosophical differences, the idea of *Techno-Economic Networks* goes at least some way in trying to account for the choices to be made and new configurations of actors that may appear. In other words, it is more concerned with the changing regulatory environment as a whole, with particular emphasis given to the use made of technology. In contrast, *Sociotechnical Constituencies* focuses on innovation and technological development and particular emphasis is given to how the regulatory environment shapes the technology. To summarise, Molina focuses primarily on the development of technology within a network, while Callon tries to explain the development of the network, and considers the role of technological development within that network.

Figure 9: The Translation of *Techno-Economic Networks*



Source: Adapted from Callon (1992a)

The language used is also different. *Techno-Economic Networks* are constituted of actors and intermediaries. Callon describes that the starting point in analysing a system through *Techno-Economic Networks* is to recognise a bundle of links and relations between heterogeneous actors who are competing and co-operating with each other. Once this system has been created the links that reinforce and shape its structure are called intermediaries. Intermediaries may be linked to a particular activity like texts, artefacts, money and natural phenomena (like the weather). Thus one *Techno-Economic Network* can 'translate' to another by means of actors working through intermediaries. Figure 9 illustrates such a process.

An actor A can transform intermediaries of rank n+1. There can be many intermediaries which can be written in the form $N(A)=Br^1Cr^2Dr^3$... N(A) signifies a network in which A is attributed with putting intermediaries into circulation (B,C and D are the intermediaries, and r^1, r^2 and r^3 are the relationships between the intermediaries). To illustrate this process, the effect of information technology on Beesley and Littlechild's 2x2 Matrix (see figure 7) shown in figure 10 shall be used (see section 4.4.6). N(A) in figure 9 could be for example a publicly run monopoly that is equivalent to quadrants A of the matrix in figure 10 and N(C) could be a competitive structure equivalent to quadrants C in the matrix in figure 10. An intermediary meanwhile could be the advance in information technology and new rules or regulations that have facilitated the creation of a new market structure. This can be signified by the transformation of an industry from Quadrant A to Quadrant C in figure 10. This principle is used in section 16.3.2 to create a guide to map the regulatory process for the forthcoming case studies.

Figure 10: Beesley and Littlechild's 2x2 Matrix shown in figure 7 with the added perspective if *Techno-Economic Networks* illustrating the role of Information Technology

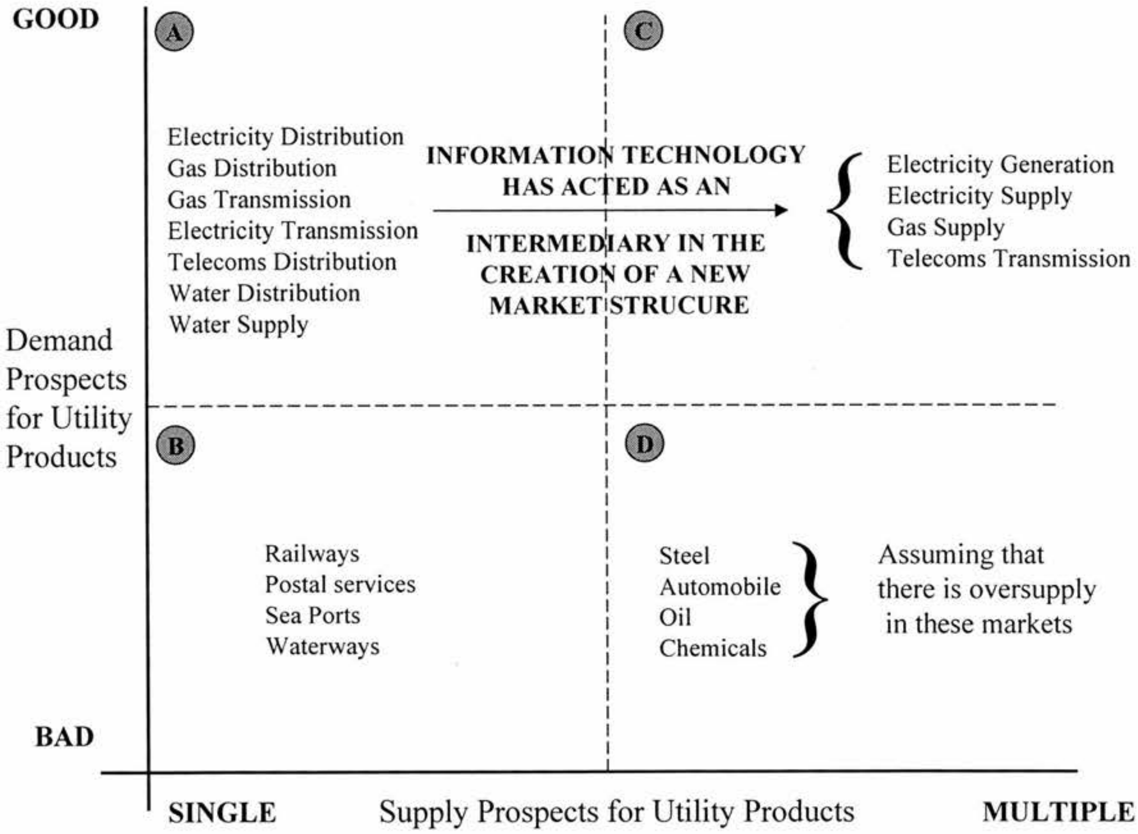


Figure 9 also shows that the translation processes can take two forms. The first involves an interpretative operation in which an actor (e.g. the UK Government) installs a new deregulated regime, facilitated by advances in information technology. This system is then seen to be more efficient than the old monopolistic system and is adopted (and refined) by a further actors (e.g. the French Government). The second involves the two *Actor-Networks* (e.g. the UK and French electricity networks) who merge due to for example European Union harmonisation and/or advances of information technology. Of course there are also other intermediaries at play other than information technology, such as culture, geography and demography, to name but a few. These are in turn inscribed in texts such as Acts of Parliament, standards and protocols. These intermediaries can be thought of as constituents, which can influence the outcome and shape, of the *Techno-Economic Network*. In terms of *Sociotechnical*

Constituencies one can therefore think of *Techno-Economic Networks* as the shifting framework (interpretative flexibility) within which a particular aspect of reality is socially constructed, but with the added complication of non-human actors. The networks thus formed can differ both in their convergence and in their degree of irreversibility. In highly convergent and irreversible networks the actors are perfectly identifiable and their behaviour is known and predictable. Normalisation is another important feature of *Techno-Economic Networks*. In a normalised *Techno-Economic Network*, links are more predicable, fluctuations more limited, actors and intermediaries more closely aligned. Thus the possibility of analytically describing *Techno-Economic Networks* depend on their degree of irreversibility, of convergence and normalisation. *Techno-Economic Networks* are not rigid and fixed forever; they can break down and give rise to different *Techno-Economic Networks*. For analysts using this theory, the analysis of concrete instances of technological change is conducted through the analysis of the associated networks and their changing properties of reversibility and normalisation.

It is clear that both the *Techno-Economic Networks* and *Sociotechnical Constituencies* approaches have differences in their philosophical backgrounds and their applicability. *Sociotechnical Constituencies* are more appropriate when considering technical change, and *Techno-Economic Networks* are used when considering system and regulatory change. It is these principles which along with *Evolutionary Theory* that are carried forward in the analysis in Part III of the thesis.

5.3.4 *Evolutionary Theory*

Donald Campbell (1965: p.27) describes three basic characteristics to *Evolutionary Theory* in the social sciences. The occurrence of variations, which may be heterogeneous, haphazard, 'blind', 'chance', 'random', but in any event variable events. This is the equivalent to the mutation process in biological evolution. Then there is the selection criteria such as selective elimination, selective propagation and selective retention, of certain types of variations. This is analogous with the differential survival of certain mutants in biological evolution. Importantly however, Campbell points out that there is a crucial difference between the selectors in science and social science. In science, the selectors are considered to be a natural phenomenon. In social science, they can be natural, social or as assumed in this thesis, a complex mixture of natural and social phenomena. Finally there has to be a mechanism for the preservation, duplication or replication of the selective retention of certain types of variations. The rigid duplication process of the chromosome/gene system is the equivalent in plants and animals. Hull (1998: pp.408-409) summarises the evolutionary process by arguing that a replicator is an entity that passes on its structure largely intact in successive replications. An interactor is an entity that interacts with its environment in such a way that this causes the replication to be differentiated. This in turn leads to selection, which is the extinction and proliferation of interactors. Campbell also suggests that the evolutionary perspective is rather undeveloped in the social sciences due to an early contamination by reactionary political viewpoints. He considers that if one is willing to consider that technology is a consequence of a mixture of natural and social phenomena, many of the political pitfalls of *Social Darwinism* can be avoided. So he dismisses the idea of the 'natural' as the only selection mechanism in the evolution of social systems. Moreover, Campbell emphasises that the natural dimension and socio-cultural melee in which knowledge is created are difficult to distinguish.

One of the most developed areas of study in evolutionary principles applied to technology lies within the economic sphere (Saviotti & Metcalfe, 1991). The most notable of these works is Nelson & Winter's *An Evolutionary Theory of Economic Change* (1982). Their proposals emphasise the inevitability of mistaken decisions in an uncertain world, and the active observable role of the economic environment in defining 'mistakes' and suppressing the mistakes it defines. Evolutionary economics starts by combining the Schumpeterian heritage, stressing the fundamental role of innovations in long-term economic development (Schumpeter, 1943), with the behavioural theory of the firm (Cyert & March, 1992). Economic and technical changes are therefore introduced and illuminated by satisficing, rather than optimising, firms. Variation is the outcome of firms' search activities and selection occurs by means of competition, though this is seen as taking place in a 'selectional environment', rather than a simple neo-classical market. The balance between search activities and the operation of the selection environment then shapes firms' behaviour.

The principles of evolution have also not escaped the attention of those attempting to describe, explain and predict technological progress (Cziko, 1995: pp.161-166). As early as 1863 Samuel Butler explored the theory that machines develop in a way that resembles living organisms. Unlike Butler's account of the evolution of machines, more recent accounts have attempted to understand the innovative process in an evolutionary light. In *The Evolution of Technology*, George Basalla argues that new inventions do not emerge magically from the minds of inventors, rather they are modifications of preceding artefacts or processes. He provides the example of Eli Whitney's cotton gin, which was 'invented' in 1793 but was based on the Indian *charka* that had been used for thousands of years to remove seeds from cotton. Basalla also points out that the diversity of artefacts varies from one society to another. The source of the diversity can be found in psychological, socio-economic and cultural factors. An example of this diversity is that more than 1000 smokestack designs were patented in the United States during the nineteenth century in the unsuccessful attempt to prevent the escape of embers and sparks from wood burning locomotives. In this way variation, retention and selection become the three essential elements of Basalla's view of technological evolution. Like Basalla, Joel Mokyr's *The Lever of Riches* suggests an evolutionary context for technological advances. In his accounts of historical case studies in Europe and China, Mokyr emphasises the growth of human knowledge. He suggests that the conceptualisation of the product or the process may be analogous to the genotype of a species while the process or product itself is analogous to the phenotype. Thus:

"The phenotype of every organism is determined in part by its genotype, but environment plays a role as well. Similarly, the idea constrains the forms a technique can take, but adaptability and adjustment to circumstances help determine the exact shape." (Mokyr, 1990: p.275)

In *What Engineers Know and How They Know It*, Walter Vincenti breaks away from the limits imposed by the rather strict biological analogy employed by Basalla and Mokyr and makes a compelling case for a more general selectionist account of technological development. A variation and selection analysis is used to account for the growth of engineering in five detailed case histories of important innovations that paved the way of the modern aeroplane. Vincenti emphasises the advantages of vicarious trials over direct trials. Direct trials are not based on any systematic attempt to learn from previous trial. Vicarious trials set up a rigorous selection process that involves experiment, analysis and simulation. Analytical vicarious trials can be even further removed from direct trials in that they use more abstract tools such as computer simulation.

A Quasi-evolutionary methodology for the management of new technology has also recently been developed by Schot (1992), Rip (1995), Rip *et al.* (1995), Rip & Kemp, (1998), Deuten *et al.* (1997), Schot & Rip (1997) and Rip & Kemp, (1998) known as *Constructive Technology Assessment*. The key to *Constructive Technology Assessment* lies in the understanding of the nature of the régimes that are surrounding the technology such as network irreversibility, social acceptability and environmental sustainability. Rip suggests a number of factors that are important in the successful introduction of a new technology. One of the factors includes strategic decision making which considers amongst other things the longer-term possibilities for a new technology in relation to existing infrastructure régimes. Deuten *et al.* meanwhile focus on the embedding in society of new products and their relevance to markets, their admissibility with regard to standards and their acceptance by the public. With *Constructive Technology Assessment*, writers like Schot (1992) propose a methodology by which socio-technical assessments can be made where the processes of variation, selection and retention are seen as interdependent activities. Schot (1992) sees that there are many (often interacting) factors which influence the development of alternative variations such as, the modification of the selection environment and the creation of the technology itself. Thus evolutionary thought is departing from a technical or social mechanism to an interactive socio-technical process. Moreover, Schot (1992) sees the role of regulation as crucial as generating variations, selecting variations and linking variation and selection. Schot & Rip (1997) then suggest that regulatory policy is dominated by two dynamics, namely, the 'society side' or the 'technology side'. An example of 'society side' domination is given by clean air legislation in California that has prompted development in electric vehicles. On the 'technology side', strategic niche management of renewable energy technologies, which allows implicit financial subsidies, has encouraged and broadened the research on renewable power generation technologies in the Netherlands. Schot & Rip (1997) go on to suggest that there should be a third strategy (which is at the core of *Constructive Technology Assessment* and is a combination of the other two) that attempts to create and exploit linkages between supply and demand (or variation in production and selection environment). In this they identify 'loci for intervention' and 'technology niches' where technology can be developed in a socially and environmentally acceptable fashion. Thus Rip & Kemp, (1998: p.365-386) suggest that rather than a regulator imposing economic, technical or social solutions, any intervention should act as a facilitator searching for alignments carried out in a co-evolutionary way.

In sections 15.3.3 and 16.3.3 evolutionary analysis is used to describe the development of technology in an attempt to draw together the commonalties of the *Sociotechnical Constituency* (chapter 15) and the *Techno-Economic Network* (chapter 16) approaches. In saying this, there are some apparent limitations to evolutionary methodology. Variation/selection activities cannot scan the whole environment, but are generally guided by previous experience. Knowledge is therefore constrained (bounded) and local (Simon, 1962). However this is arguably of only limited importance in technological development since patterns and rigidities exist which constrain the behaviour and routines so that decision rules can be identified. These involve technological trajectories and régimes (Nelson & Winter, 1977) and Rip & Kemp (1998: pp.360-362), dominant designs (Abernethy & Utterback, 1975 and 1978), technological guideposts (Sahal, 1981) and technological paradigms (Dosi, 1982). Nonetheless as Green *et al.* (1999) and Rip & Kemp (1998) point out any analysis in technology must capture the flexible and should not be rigid as in a Paradigm. Thus *meso*-level approaches such as inter-sectoral studies should be informed by both paradigms such as the *Techno-Economic Paradigm* and more closely focused with work within *Systems Theory* such as *Socio-technical Constituencies*, *Techno-Economic Networks* and *Evolutionary Theory.*

Table 3: A Comparison of Theories of Technological Change

	Philosophical Foundation	**Primary Focus**	**Dimensions Considered**	**Treatment of Knowledge**	**Time**
Sociotechnical Constituents	Sociology of Scientific Knowledge	Technological Development Within a System	Social Process: Human	Bounded to the Social Dimension	Static
Techno-Economic Networks	Semiotics	Actors Involved in System Change	Social Process: Human and Non-Human	Bounded in Symbols/ Artefacts	Static
Evolutionary Theory	Variation / Selection / Retention	Change Occurring Within Systems	Multi-Disciplinary: Human and Non Human	Bounded in Social and Natural Phenomena	Dynamic

5.4 CONCLUSION

This chapter has reviewed some of the relevant literature on technology studies. It has concluded that the literature is diverse and that there are many valid ways of approaching the subject of technological innovation. It is also concluded that one approach alone will not suffice in providing the business analyst a rounded picture of the interrelation of technology and public utility regulation. This is due to their different philosophical foundations or their focus of study (e.g. technological change vs. system change or social vs. economic dimensions). Out of the literature five approaches have been chosen for the basis of the analysis of the case studies presented in chapters 14, 15 & 16. These are the versions of the *Systems Theory* presented by Hughes and Saehney, *Sociotechnical Constituencies*, *Techno-Economic Networks* and *Evolutionary Theory*. These approaches are all examined within the framework of the *Techno-Economic Paradigm* presented in section 3.4. The merits of each of the approaches studied, both for descriptive, explanatory and prescriptive methodologies, are then presented in the final conclusions (chapter 17) of the thesis.

PART II

THE CASE STUDIES

CHAPTER 6

CASE STUDY No.1:

ELECTRICITY IN THE UK

6.1 INTRODUCTION

Before 1947, there were 560 electricity suppliers in the UK, of which around a third were privately owned (Hannah, 1979). In 1947 the electricity companies were nationalised and the Central Electricity Authority (CEA) was formed. It took responsibility for the generation, transmission, distribution and supply of electricity in England and Wales. The CEA formed 14 Area Boards (two of which were Scottish) who were responsible for the distribution of electricity in their own regions. In Scotland, two vertically integrated, independent companies were formed: The South of Scotland Electricity Board (SSEB) and the North of Scotland Hydro-Electric Board (NOSHEB) (Surrey, 1996: pp.3-13 and McGowan & Thomas, 1992: ch.12).

The Electricity Act of 1957, which separated the functions of generation and supply from the co-ordination and control of the system as a whole revised this structure. The Central Electricity Generating Board (CEGB) was set up to handle generation and transmission including most of the conventional and nuclear generating plant in England and Wales. The Area Boards had responsibility for distributing electricity through low and medium voltage as well as selling it to domestic, commercial and industrial consumers in their geographical regions. The prices were presented mostly in the form of published prices, derived from bulk supply tariffs that the CEGB charged the Area Boards which were based on marginal-costing principles. The Boards also operated electrical retailing businesses (Surrey, 1996: pp.3-13 and McGowan & Thomas 1992: ch.12).

In the late nineteen-seventies and early nineteen-eighties it became apparent that the ministerial policy of marginal-cost pricing was not providing efficiency benefits and was effectively giving an implicit subsidy to the coal industry. Furthermore, a 1981 Monopoly and Mergers Commission (MMC) report stated that, in addition to the cost pricing and subsidy problems, the industry required large investments in infrastructure and monitoring of the cost of such infrastructure (Henney, 1994). This heralded the infrastructure changes that will be discussed further in this case study.

6.2 INFRASTRUCTURE

6.2.1 A Brief History

In February 1988 the Government published its plans for the restructuring and privatisation of the electricity industry in the UK. The restructuring involved: the splitting of generation from transmission; liberalising the generation market; establishing a series of privately owned regional monopolies for distribution; and the liberalisation of supply.

To this end, the CEGB was divided into three parts. The National Grid was separated from the generation industry, and is now owned by the National Grid Company (NGC). The 12 Regional Electricity Companies (equivalent to the old Area Boards) owned the NGC in turn, each holding a stake according to their size. The fossil fuel power stations were split between two companies: National Power, which was to take 70% of the generating capacity, including nuclear-powered generation plants, and PowerGen, which would take 30%. These two companies were to compete with each other and with independent power providers. Competition was also introduced into generation and supply with non-discriminatory access to national transmission and local distribution systems. A Pool was set up involving daily bidding and a half-hourly market (Surrey, 1996). The Pool is essentially a 'spot market' on which suppliers purchase electricity from the generators. The Pool has allowed competition in an industry that requires extremely fine technical co-ordination between each stage of the supply process.

In the light of considerable debate, the nuclear plants were considered to be unsaleable, and were subsequently withdrawn from the privatisation process. In December 1989, the Government announced a revised structure, with two new companies, Nuclear Electric and Scottish Nuclear, created to own and operate English and Scottish Nuclear power stations. Under this structure, National Power was left with about 50 % of total generating capacity. On 31 March 1990, the new structure was introduced and in December 1990 the 12 English and Welsh Regional Electricity Companies (RECs) were privatised. This was followed by the sale of sixty per cent and forty per cent of the shares in National Power and PowerGen being floated in March 1991 and March 1995 respectively. Further in April 1995 the Government announced its intention to privatise the nuclear plants. In preparation for the sale, the nuclear sector was restructured and Nuclear Electric and Scottish Nuclear ceased to exist. A new holding company, British Energy now owns the AGRs (advance gas-cooled reactors) and the PWR (pressured water reactor) formerly owned by these companies and was duly privatised in 1996. Meanwhile, the old magnox plants have been placed under the ownership of Magnox-Electric and retained in public ownership (McGowan & Thomas, 1992).

In order to secure the future of the nuclear plants, each Regional Electricity Company is required to obtain a proportion of its power supplies from non-fossil fuel resources. A fossil fuel levy (FFL) on electricity prices was subsequently introduced to compensate those companies for the additional costs of such power. This levy is in effect a tax to subsidise the nuclear sector and prevent it from making a loss (mainly due to spiralling decommissioning costs). Following the flotation of British Energy the FFL levy has been reduced and now stands at 2.2 pence in the pound to continue to help fund alternative renewable energy sources that would otherwise not survive in the market. Furthermore, Magnox Electric is likely to continue to receive subsides from the FFL (*Electricity Association*, 1997).

In Scotland, SSEB and NOSHEB were privatised as vertically integrated companies ScottishPower and Scottish Hydro Electric. Each has a mix of generating capacity. They own and operate the monopoly transmission and distribution functions in their areas and have retail supply functions. Both of these companies have undergone considerable expansion since privatisation. ScottishPower for instance, is now a multi-utility and has purchased one of the England and Wales RECs (MANWEB) and Southern Water, as well as having interests in gas (Caledonian Gas) and telecommunications (Scottish Telecom).

Until March 1992, Northern Ireland Electricity both generated and distributed electricity in the province. In 1992 its four power stations were sold: Kilroot and Belfast West to Nigen, a joint venture between the Belgian Powerfin and AES Electric; Ballylumford to a subsidiary of British Gas; and Coolkeragh to a management-buyout team. Northern Ireland Electricity is now left with responsibility for distribution and supply only (McGowan & Thomas, 1992).

6.2.2 Regulation

The Office of Electricity Regulation (Offer) is responsible for the regulation of the electricity industry in the UK. Set up in 1990, it is headed by The Director General (DGES) who is appointed on a four year basis by the Secretary of State for Trade and Industry. Offer now has over 200 employees, of whom approximately half are based in regional offices across the UK to deal with complaints, and the other half at the head office in Birmingham. The office is financed by annual fees, which translate to a cost of around 40 pence per customer per annum (MacKerron & Boira-Segarra, 1996).

Offer's statutory duties are defined in Section 3 of the Electricity Act 1989. They are: to ensure that licensees can finance licensed activities; to promote competition in generation and supply; to protect the interests of customers with respect to pricing, ensuring the quality of supply by the meeting of specified customer service standards; and to maintain the reliability and continuity of supply. More simply, these duties can be stated as protecting the consumer and promoting competition, whilst allowing the regulated companies to earn a reasonable rate of return (Henney, 1994: ch8).

The discretion of the Director General is not, however, unfettered. A licensee can refuse to accept a proposed change and appeal to the Monopolies and Mergers Commission (MMC), and in some cases a licensee can force the Director General to refer the matter to the MMC if a condition is to continue to apply. There is also a right of appeal to the Parliamentary Ombudsman on grounds of maladministration for not dealing with the issue in a proper manner (Henney, 1994: ch.8).

Amongst Offers' responsibilities is financial regulation. RPI-X price controls are use by the regulator to control prices of monopolistic parts of the system (see section 4.4). RPI-X is effectively a cap on the average price per kWh of electricity transmitted, distributed or supplied. The X factors are set by the regulator and were initially set for three, five and four years respectively for transmission distribution and supply, although the regulator has the option to review the X factors sooner. The initial values for the 'Xs' for privatised electricity companies were set by the Government in a bargaining process with the directors of the companies. The outcome reflects the choice that the Government made between the interests of customers and lower prices, the taxpayers' interest in higher proceeds from the sale, and the interests of future shareholders in growth earnings. Subsequently on review by the Director General the Xs have invariably been tightened (Henney, 1994: ch.8).

6.2.3 The Electricity Market

Generation of electricity supplied to the National Grid after privatisation has been dominated by the three largest UK generating companies, which were originally split off from the pre-privatisation monopoly: National Power; PowerGen; and British Energy. Despite competition amongst generators being allowed, and the growing number of small, independent generators, the market in the generation sector has been slow to develop. Tables 4 and 5 show the energy mixes and market shares in the UK.

Table 4: Energy Mix Used for Electricity Generation in the UK (%)

	Coal	Nuclear	Gas	Oil	Hydro	Other
1989	64.5	23.6	0.7	9.4	0.5	1.2
1995	48.0	28.4	16.7	4.8	0.6	1.5

Source: *Electricity Association* (1997: p3)

Table 5: Market Shares for Electricity Generation in England & Wales

	NP	PG	Nuclear Electric	Magnox Electric	First Hydro	Independent Generators
Net Capacity at 31 March 1996 (MW)	19,269	15,282	7,128	2,989	2,088	5,924
% Share of Total UK Capacity	30	24	11	4	3	9

Source: *Electricity Association* (1997: p6)

PowerGen and National Power are by far the largest fossil-fuel generators and continue to dominate the market, which contributes to the peak load (marginal plant). One of the main concerns has been that National Power and PowerGen have had the ability to alter Pool prices in the electricity generation market. Although competition in generation has been increasing, in practice the two large fossil fuel generators have a considerable amount of market power. Effectively they have been setting the Pool price except when the pumped storage plant (in Wales) is at the supply margin. Accordingly under the threat of an MMC reference, an agreement was obtained that National Power and PowerGen would divest 4GW and 2GW respectively of coal and oil-fired plant by December 1995, which would double the level of independent competition. By April 1996, PowerGen had sold two of its generators to Eastern Electricity, and National Power had agreed to lease three of its power stations to Eastern Group over a 10 year period, at a cost of around 1.7 billion pounds (McGowan & Thomas, 1992).

Vignette I

One of the problems of electricity generators is that nearly all the major forms of electricity generation potentially produce major environmental hazards. Fossil fuel plants produce gaseous by-products such as SO_2 and CO_2. Nuclear plants potentially have a more obvious danger, as witnessed at Chernobyl in the Ukraine. The problem in the UK has been side stepped in a rather ingenious way but prompted by EU legislation that allowed gas to be used in power stations for the first time. As a result there has been a dash to build new CCGT (combined cycle gas turbine) generators in the UK supplied by its considerable indigenous gas resources. The total capacity had risen to 6,900MW in 1995 from virtually nothing in 1989. Since this, gas generation has replaced ageing coal stations, which has enabled the UK to conveniently cut SO_2 and CO_2 emissions. Nevertheless this reduction in coal capacity has had a less savoury knock-on effect in society. In particular, it causes highly visible unemployment (e.g. in the coal industry). This caused the Labour Government which was elected in May 1997 to call a moratorium on the building of new gas-fired power stations and conduct a

widespread review of energy policy, and in particular the Pool.

(Sources: Interviewees: Margaret Doak, DA/DSM; Mike Eggleton, UKDCS; and MacKerron & Boira-Segarra, 1996)

With a few exceptions, all electricity in England and Wales is now traded through the Pool. ScottishPower, Hydro-Electric and Electricité de France (EdF) also participate in the Pool, buying and selling through interconnections with the National Grid. Each day, generators bid their prices for the following day. The National Grid Company assimilates the prices offered and decides upon the capacity required from each generator in order to meet forecast demand plus a margin for reserve with the aim of balancing electricity requirements across the country. The price of electricity changes each half hour and is based on the highest offer price plus a 'capacity credit', which is intended to encourage investment in new generating plant.

Vignette II

Due to the concentrated nature of the generation sector in the UK electricity industry, the Pool Purchase Price may be unnaturally high and not reflect marginal cost pricing. In order to smooth out the price fluctuations inherent in this system, large generators and suppliers of electricity tend to prefer to set up long-term contracts. These are known as contracts for differences, since the supplier or buyers pays the difference between the Pool price and the contract price. The principle of most of the financial contracts is a two-way option. The price for supply is fixed at an agreed level. Should the half-hourly Pool price differ from that agreed, then either the generator will make up the difference or the supplier will refund the difference, depending upon whether the Pool price is below or above the agreed price.

(Source: Interviewee: Mike Eggleton, UKDCS)

Transmission in the UK (which accounts for around 5 per cent of final electricity costs: see figure 6) involves the transfer of electricity from the generator to the grid supply point (GSP) accessed by the local supplier, usually the Regional Electricity Company. The 1989 Electricity Act requires a transmission licence holder to develop and maintain an efficient, co-ordinated economical supply of electricity to facilitate competition in the supply and generation of electricity. The National Grid Company (NGC) is the only transmission licence holder in England and Wales and it operates the 275kV and 400kV transmission system. NGC is also required to offer terms for connection, and use of the transmission interconnections between Scotland and France. Users of NGC's network pay NGC 'use-of-system' charges that are subject to a price control formula (RPI-X). NGC is also required to produce a *Seven Year Statement* (SYS) which is updated annually. The SYS sets out technical information concerning the capacity and physical characteristics of the transmission system. At the time of privatisation in 1989 ownership of the NGC was shared between the distribution companies (the RECs). In December 1995, the separation went further with the RECs' holdings of the National Grid being floated on the Stock Exchange.

Table 6: The Percentage Contribution Each Function makes to the Final Electricity Price before the Fossil Fuel Levy was reduced in 1995

Demand (MW)	Generation	Distribution	Transmission	Supply	FFL
<0.1	52	26	5	7	10
0.1-1	59	22	5	4	10
>1	69	15	5	1	10

Source: Thomas (1996)

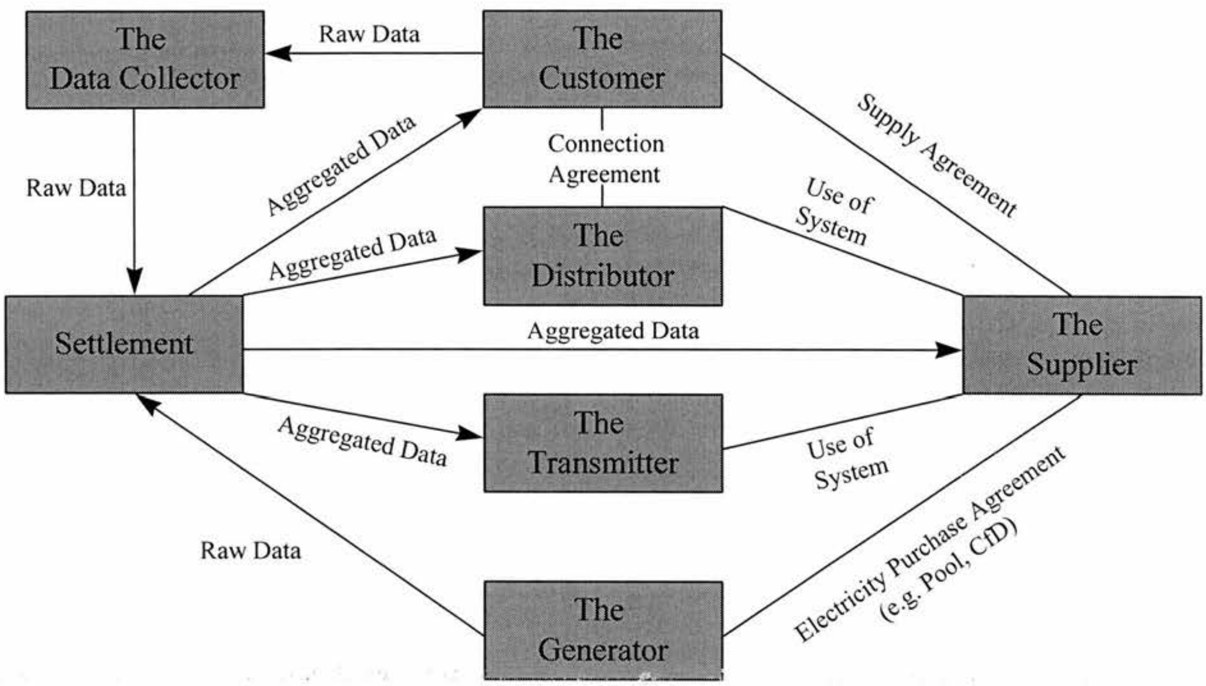
Scotland has two transmission systems, owned by ScottishPower and Scottish Hydro-Electric. The two systems are connected to each other by a number of interconnectors. ScottishPower's network is also connected to the National Grid in England and Wales, allowing it to generate or withdraw electricity as appropriate (*Electricity Association*, 1997).

Distribution is the term used to describe the transfer of electricity over lower voltage circuits from the transmission system to customers. There are 12 Regional Electricity Companies (RECs) in England and Wales who are the monopoly providers of a distribution infrastructure in an authorised area. These systems comprise the 240V networks for supplying domestic customers and the higher voltage networks up to and including 132kV networks. Each REC has a Public Electricity Licence, which requires the licensee to develop and maintain an efficient, co-ordinated and economical system of electricity supply. The licence requires each Public Electricity Supplier (PES) to publish a Distribution Code, which sets out the technical and operational requirements for plant connected to the PES's own network, and describes how the system should be operated and developed. Initial licences have a minimum duration of 35 years and the Secretary of State is required to give 25 years' notice of termination (*Electricity Association*, 1997).

Each REC distributes electricity for its own supply business and for second tier suppliers whose customers are within its area. This system of *Third Party Access* requires the REC to offer terms of connection to, and 'use-of-system' on a non-discriminatory basis. The charges for this 'use-of-system' are subject to a 'RPI-X' price control formula. At privatisation the Government retained a golden share in these companies, but this ran out in 1994. Since then they have attracted a great deal of take-over activity, especially from companies from the USA (*Electricity Association*, 1997).

Supply is the term used to describe a REC's role in providing sufficient electricity to the end user. Supply consists of passing on appropriate charges for generation, transmission and distribution costs, metering charges, setting tariffs and promoting the safe and efficient use of electricity. The supply market has successively been liberalised. In 1989 customers with demand over 1MW were allowed to purchase their electricity supply from a company other than their own REC. The franchise limit was dropped to 100kW in 1994 and was abolished completely in 1998. As a result of the commercial and regulatory arrangements electricity supply is now, in principle, a competitive business (*Electricity Association* 1997). Figure 11 summarises the contractual arrangements in the liberalised UK electricity market.

Figure 11: A Diagrammatic Representation of the Contractual Arrangements of the Deregulated Electricity Market in the UK



6.3 METERING

6.3.1 Metering Policy Pre 1990

From the early days of electricity, the peak load problem has been present and the need to provide an appropriate pricing policy recognised (see section 4.3.1). Initially customers were not individually metered but were charged fixed rates or rates that varied by the number of light bulbs, etc. The simple, electro-mechanical meter, the familiar spinning-disk variety still in use around the world today, was invented in 1888 but did not become widely used until some time later (Hannah, 1979).

Vignette III

Metering technology remained much the same until the nineteen-seventies and nineteen-eighties when there was a period of rising energy prices that reduced electricity growth rates. In response, energy conservation, demand side management and energy efficiency programmes grew in number. Demand for more sophisticated meters, demand recorders, one-way and two-way communication devices grew substantially as power companies actively started to study and modify customer energy consumption. Meter manufacturers responded by embarking on several approaches to the growing need for more accurate meters with data collection and 'time-of-use' capabilities, and meters with remote reading and diagnostic capabilities:

"The purpose was to optimise generation and the load profile."
(Source: Interviewee: Alan Dick, Electricity Association)

It was not until the electricity industry in the UK had become nationalised and fully integrated in the nineteen-fifties that any large-scale programme of load management could play a part. Since, in general, electricity must be consumed as soon as it is produced there must be enough generation, transmission and distribution capacity to meet the maximum instantaneous demand. In practice this maximum demand should only occur once a year which means that for most of the time there is plant lying idle. A measure of this efficiency of the system is called the load factor, which is given by the formula:

$$\text{Load Factor} = \frac{\text{Average kilowatts over the year}}{\text{Maximum kilowatts during the year}}$$

Source: Turvey & Anderson (1977: p.347)

Vignette IV

To counter the load factor problem 'time-of-use' (TOU) was introduced. Also for large consumers, in addition to the conventional standing charge and energy charge, a maximum demand charge was levied to make customers aware of the impact on the system. TOU tariffs were charged at marginal cost when the system was under utilised. Examples of these were evening and weekend tariffs for pubs and clubs and the *Economy 7* tariff, which charged storage heaters at times of low demand. The metering technology used for these tariffs varied but usually entailed two meters, one for the standard rate tariff and one for the off peak tariff, with the off-peak meter (and circuit) being controlled by an electro-mechanical time-clock.

(Source: Interviewee: Ian Pope, Ian Pope Associates)

Amongst large industrial consumers of electricity where the possibility for load management was greatest TOU pricing was supplemented by half-hourly demand recorders, which were recorded on a roll of paper similar to ticker tape.

"Away back in the sixties and seventies the collection of large amounts of data was not really feasible. The cost of metering was quite high and time of day metering and half hourly metering had to be manually fed in. So this was not used except for the very largest customers and then it was used more to provide a maximum demand charge rather than relating the price to the marginal cost of the supply... The tools we used to do this were pretty clumsy."

(Source: Interviewee: Ian Pope, Ian Pope Associates)

The next advance came with the gradual introduction of teleswitches to replace timeswitches on the meter. Teleswitches differ from timeswitches in that they are switched remotely through some form of communications device. In the UK the radio network was exclusively used. Teleswitches gave the electricity utility greater flexibility in the way they could switch on and off load. For example the time clocks all tended to switch on at the same time, teleswitches allow this to be staggered. Teleswitches also allowed more flexible tariff regimes in that load could be switched on and off outside the time clock settings.

Vignette V

In 1986 the Electricity Council[4] were involved in trials in energy management systems, particularly, radio teleswitching.

"The industry could speak with a single voice through the Electricity Council and say to the manufacturers that the future was in electronic metering. This encouraged the major manufacturers like GEC and Schlumberger to go into commercial production of radio teleswitches so they became commercially available. GEC and Schlumberger also had an agreement over three or four years before the others could come in. That was the reward for being the developers."

(Source: Interviewee: Alan Dick, Electricity Association)

"An example of metering technology taking the lead was the development of the

[4] The electricity industry trade association, later to become the Electricity Association.

two-element meter and teleswitch that ScottishPower and Scottish Hydro utilised. This truly used teleswitching as dynamic switching. It provided a 24-hour separately switched, separately metered system all in one meter box. The radio teleswitch drove some of the innovative tariffs in the late nineteen eighties which utilised the peak demand on their integrated supply network."

(Source: Interviewee: John Heathcock, Schlumberger)

Another fundamental approach was to develop a new generation of 'solid-state' meters with no mechanical moving parts and additional capabilities such as data-collection and retrieval. In particular, the Electricity Council encouraged Schlumberger in a trial of low cost domestic electronic meters:

"There were trials of several hundred of these all over the country."

(Source: Interviewee: Alan Dick, Electricity Association)

These electronic domestic meters have been available on the market since 1984, and are very gradually replacing traditional electro-mechanical (Ferraris disc) meters. A parallel revolution was also taking place to make it possible to read meters faster, more accurately and remotely. Hand-held computers that record and, in some cases actually read meters, advanced by the late eighties to the point where some can now be ready by simply holding a sensor against a port on the meter. This reads the contents and stores it on a portable computer for subsequent billing and data analysis. This has now moved on to mobile systems on the market now, that allow a van driving along to pick up readings from especially equipped meters from homes on the street. The final step is where the meter readings are down-loaded via a radio link to base stations covering a whole town for billing. Trials are also being carried out using the telephone network and mains-borne communication. These more ambitious developments however, have so far been limited to relatively small-scale experiments.

By 1988, on the eve of deregulation, all manufacturers had stopped producing

electro-mechanical meters. At this point "we (the UK) led the world" in electronic forms of communication.

(Source: Interviewee: Alan Dick, Electricity Association)

However there were two snags:

"The tremendous work done in the eighties by Schlumberger to introduce the electronic single phase meter was undone by a failure of the technology and the pressures of privatisation to conserve cost."

(Source: Interviewee: Brian Bates, AMPY)

and

"The bulk standard electro-mechanical meter only cost £15...Unfortunately some of these early electrical devices were costly (£200) designed down to a low cost figure so that there were reliability problems."

(Source: Interviewee: Alan Dick, Electricity Association)

As a result it was necessary for meter manufacturers to withdraw from service a very large number of electronic single-phase meters in the late eighties and early nineties.

"The measuring technology had gone pear shaped. There were widespread failures or potential failures, which the utilities could not tolerate...In addition from the utility's point of view they had to provide the means for the development of competition in a deregulated market by a certain date and these failures were a hindrance."

(Source: Interviewee: Brian Bates, AMPY)

6.3.2 The 'Over 100kW' Market

Since 1994, consumers both over 1MW and 100kW, have been able to negotiate individually for their electricity supplies. This has meant that instead of prices being produced based on marginal cost principles, it has been left to the market itself to define the price of electricity. The role played by metering in the success of this newly created market is crucial. These new arrangements mean that a network of contractual relationships have been set up requiring more metered data which is provided quicker than has hitherto been necessary.

Second tier customers receive their electricity externally through the existing grid and their local distribution system provided by their local RECs. The amount customers consume is metered at half hour intervals. Metered data are collected, processed and send to the supplier by United Kingdom Data Collection Services (UKDCS), acting as an agent to the Settlement Administrator of the Electricity Pool. There are estimated to be 55,000 sites in the United Kingdom with an electrical load in excess of 100kW. Of these 25,000 are now in the second tier. A further 10,000 sites are believed to be in first-tier supply (i.e. purchasing electricity directly from their regional electricity suppliers, but with second-tier metering equipment installed).

Bringing competition to the supply side of the electricity industry is made possible by, and is wholly reliant on, advanced digital metering and communications, as well as some extensive systems of data collection and analysis. To illustrate the scale of the system, Eastern Electricity currently processes data from some 5500 second-tier sites every day. This equates to 1.6 million half hourly readings each week. Meanwhile, the reliability of remote data collection is better than ninety-eight per cent.

Vignette VI

In this system certain codes of practice have been established. All consumers over 1MW and all consumers taking a second tier supply over 100kW require half-hourly metering. Every second tier site has to have a Code 3 or Code 5 approved

meter with a bespoke communications link. These are installed commissioned and tested by meter operators approved under the UK Electricity Pooling and Settlements Agreement.

(Source: Interviewee: Alan Dick, Electricity Association)

"The codes of practice have been developed by the Electricity Pool to cover the competitive market. The idea was that the Pooling and Settlement Agreement would require certain accuracies in metering, depending on the certain classes of customer. It contained schedules, which gave a summary of those accuracies but we agreed that there would need to be some more detailed documents to spell out the physical engineering requirements. So codes of practice 1, 2 and 3 were developed from some earlier codes of practice from the bulk side of metering. Codes 1 and 2 cover generator metering, distribution metering, transmission metering and bulk supply metering. Code 3 is for very large customers, 1MW and above. Code 5 metering is the 100kW market and Code 6 is metering for the domestic market."

(Source: Interviewee: Alan Dick, Electricity Association)

The introduction of competition in the 'over 100kW' market was not without its problems:

"The regulator was given a lot of 'duff gen', and he thought the meter was a much simpler device than it actually is. The system nearly collapsed. It needed some people to come into Offer who were less purist in their liberalisation views. You need discipline, and discipline in not a word that regulators like if they are deregulating."

(Source: Interviewee: Mike Eggleton, UKDCS)

Nonetheless large electricity users in the UK are now enjoying reduced prices for their electricity, but whether the system is more efficient is debatable.

"Clearly the 'over 100kW' market has responded to pricing signals, and load factor has been increasing because of this. So there is a clear demonstration that the large customer does respond to price signals in its metering. However, I think because we have moved from a system where costs were measured in the public sector way including social provisions, to one in which cost is paramount, I am not sure that you can measure all that accurately what the reduction of costs has been.

I think that you can rest on the fact that you have a market which is much better at disclosing costs than in previous systems and people are responding to those costs, so it can be deduced that the system is a lot more efficient. Whether you can sit down and do an audit of the system, to prove that it is more efficient is a different story. I am not sure that you can."

(Source: Interviewee: Ian Pope, Ian Pope Associates)

Another issue when considering the benefits (or otherwise) are the effects of contributory factors that have happened over the past twenty years in the UK. The move away from an industrial base to a service based economy or the 'dash for gas' in electricity generation and basic demographic changes may have played their part.

"It is a combination of factors. There is an underlying way that society goes about things. For example the amount of street lighting has increased. This makes better use of the assets at night time when demand is low. So whether that can all be put at the feet of metering and price signals I am not sure. Be cautious, there are a number of factors going on here!"

(Source: Interviewee: Alan Dick, Electricity Association)

6.3.3 Profiling

From 1 September 1998 all twenty-five million electricity customers in the UK began to be eligible to take competitive supply. When plans were being developed for the competitive market in domestic electricity it seemed that the next logical step would be, that any customer changing from their local Public Electricity Supplier to a new supplier would require to install half-hourly metering and an associated communication device (Offer, 1992). Offer decided however, "in order to encourage competition" in the new market, that the 1998 trading arrangements would not require half-hourly meters to be installed and the trading would be administered by the Initial Settlement and Reconciliation Agreement. The reasons for this change in tack towards metering technology were twofold. First, the difficulties experienced in the 100kW market suggested that the practical experience of the installation of such devices might cause such confusion that it endangered the purpose of the exercise which, it was to introduce, namely competition. Second, and more important, the costs of installing such meters are significant for smaller customers and this would be likely to restrict the freedom of customers in choosing their own supplier. Half-hourly electronic meters cost between £200 and £300 compared to £10 to £15 for an electro-mechanical meter, while the average domestic electricity bill is around £300 per annum. This is a classic 'catch 22' situation. If half-hourly metering was to be installed, new products and services could be developed to encourage competition. Yet if the installation of these is too high, the customer is unable to bear the cost.

Instead it was agreed that the 1998 trading arrangements would make cost-effective use of a small number of generic profiles to represent the demand for large populations of similar customers. These populations are called 'profile classes'. Each customer who is not equipped with half-hourly metering is allocated to one of eight 'profile classes' at the beginning of the new market. As the market develops, the initial eight classes may be modified and/or new classes developed. With the decision to use 'profile classes' one of the opportunities to develop an integrated metering, communications, and multimedia network has stalled, in the UK electricity industry. It is unlikely to be economic for one customer to choose an electronic meter for their electricity supply alone. Similarly it is unlikely to become economic for one customer to choose a mains-borne signalling system and a neighbouring customer to choose a radio teleswitch system.

Vignette VII

The change of role that metering has had on the deregulatory process caused many ironic comments:

"If you go back in history to 1994, Offer were making all sorts of noises that

metering and communications were going to solve all sorts of problems for 1998. Offer went very cold on that in 1996 and on the run up to 1998 nothing has been heard of at all. Companies are not going to invest in systems that are not going to pay for themselves."

(Source: Interviewee: Nigel Orchard, Pilot Systems)

The decision to opt for profiling has undoubtedly been an inhibitor to the development of metering technology and has caused a number of dramatic comments:

"Profiling was the final kiss of death for electricity metering... It cost GEC their company. For Schlumberger it cost them their growth and future in the UK."

(Source: Interviewee: Craig Howarth, ABB Kent)

"There are fears that suppliers can use such profiles to 'cherry pick'." This means that suppliers will select only the more profitable customers to supply resulting in a two tier system.

(Source: Interviewee: John Cooper, Offer)

Even Offer admits that:

"Profiles are definitely a compromise."

(Source: Interviewee: John Cooper, Offer)

Nevertheless there is a general optimism that the bottleneck which is being seen in the domestic market is just a temporary phenomenon. Once the profiles are in place suppliers may wish to build new profiles on the back of more sophisticated metering to optimise their energy portfolio:

"Then you can have profiles for weekends, profiles for public holidays and lifestyle profiles etc. Profiles should be seen as the a starting point."

(Source: Interviewee: John Cooper, Offer)

There is also the issue of how the Pool works as it requires data on a daily basis,

and this may not be suitable for competition on the domestic market.

6.3.4 The Liberalisation of Meter Operation

The role of meter operator was established by the regulator in 1992 as a separate business for the 'over 100kW' market. The meter operator is responsible for the provision, installation and maintenance of the meter. Until then the host REC had a *de facto* monopoly of the meter operation role. This was changed, and the meter operator role was made competitive so that customers could appoint their own meter operators. Since the abolishing of the franchise market in 1998, the meter operator has been appointed by the Supplier. The liberalisation of meter operation is proposed to be spread to all electricity customers from 1 April 2000 (Offer, 1997: pp.21 & 22).

Vignette VIII

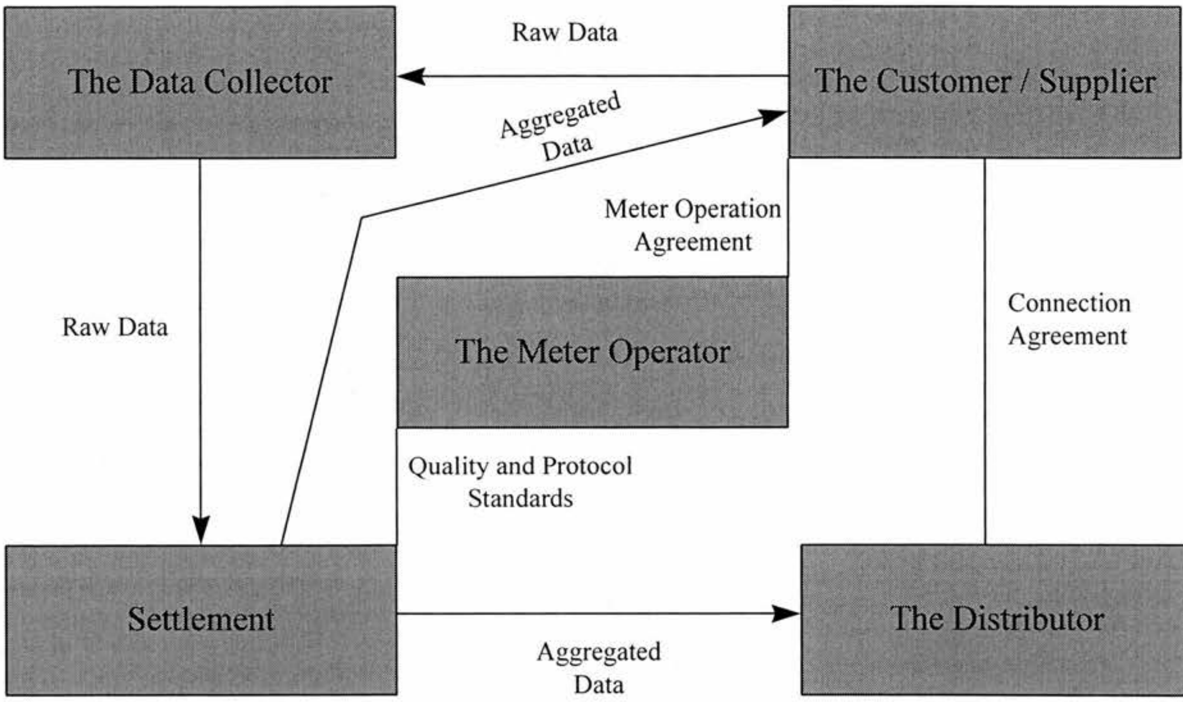
In Offer's words:

"We are very keen to see competition in electricity metering. The Director General in 1992 enabled any customer to own their own meter to facilitate competition in meter operation for half hourly metering. So there are separated regulated businesses in each REC offering metering services."

(Source: Interviewee: John Cooper, Offer)

In practice little competition has emerged. There are only four licensed meter operators in addition to the RECs and only one of these meter operators Datum Solutions (a National Grid Company who have 12,000 installations) have any market penetration. In saying this some RECs have national facilities in addition to their activities in their own distribution area. One of the reasons for the lack of competition was the problems associated with installing half-hourly meters when the 'over 100kW' market was opened up to competition.

Figure 12: A Diagrammatic Representation of the Contractual Relationships in the Meter Operation and Data Collection Markets



Vignette IX

"There was mayhem in 1994 when the 100kW market opened, there was no doubt about it that Offer did not understand the problem and they kept insisting on the purity of competition in meter operation roles. Consequently some companies were in that business who had no idea what they were about and it was a disaster... Even Datum Solutions who only had experience in transmission metering suddenly found that there was a lot more difficulties to customer metering than they ever thought."

(Source: Interviewee: Mike Eggleton, UKDCS)

Even Offer have found it disappointing:

"They (the RECs) clearly have got a monopoly at the moment. What was disappointing to me was that meter manufacturers have talked and are still talking of offering a complete package for installing meters and reading meters. Manufacturers are in a dilemma because they are tied in to their own make of meters for installation purposes."

(Source: Interviewee: John Cooper, Offer)

Representatives of the RECs are very keen to point out that there is a regulatory vacuum here:

"A REC will not invest in new metering if they think that they are going to loose their metering business in 2000."

(Source: Interviewee: Margaret Doak, DA/DSM)

This is a phenomenon of stranded assets and is key both to the development of metering technology and the liberalisation of the meter operations market. A solution could be that the meter operation function is split into its subfunctions of meter ownership, meter installation and meter maintenance. So in effect the meters would be owned by a financial leasing company and the operation and maintenance conducted by sub function. For example, when the railway system was privatised, the fixed infrastructure was vested in Railtrack and the rolling stock was sold to Roscos (Rolling Stock Leasing Companies) who lease the assets to train operating companies.[5] Nonetheless, the final shape of the meter operation business in electricity is still unclear but one thing that is certain is that the stranded assets issue has caused a great uncertainty in the meter operations market and has inhibited technological development:

"Prior to 1998 electricity companies seemed to be going along quite happily installing meters. Then it dawned on them by 1998 they may not be owning the meters in the future so they all went to the cheapest and most simple meter available."

(Source: Interviewee: Craig Howarth, ABB Kent)

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[5] There are three Roscos: Angel Train Contracts Ltd owned by The Royal Bank of Scotland; Eversholt Leasing owned by The Hong Kong and Shanghai Bank; and Porterbrook Leasing Ltd. owned by Stagecoach.

Others believe that the insistence in developing a meter operation market is not only in inhibiting technology but also inhibiting competition in the domestic market:

"It could have been handled better by Offer. If they had defined the job of the distribution business to provide a connection to the premises and half-hourly information on the consumption of that premises. That function then becomes part of the monopoly distribution business. The supply business is then in the business of purchasing electricity, arranging contracts with the distribution business, collecting the money from the customer and paying the distribution business. Then you could create a market where every customer could have had half hourly metering at really a very cheap price."

(Source: Interviewee: Ian Pope, Ian Pope Associates)

6.3.5 Data Collection

For purposes of settlement between suppliers in the 'over 100kW' market, the Pool Settlement System Administrator (SSA) requires the meter readings from second tier customers' half-hourly meters. These readings are aggregated to determine the bills of second tier suppliers. These are then deducted from the total amount of electricity purchased from the Pool at each grid supply point in order to calculate the public electricity supplier's bills. Consumers need suitable communications equipment (usually a modem or Paknet installation) to be taken on a daily basis for Pool settlement purposes. The franchise for data collection for the SSA is put out to competitive tender on a periodic basis.

Vignette X

United Kingdom Data Collection Services has been awarded the franchise up until 2000 for data collection for the 'over 100kW' market. Over the past ten years a UKDCS has grown from a handful of people to nearly a hundred. It collects each night over 48 half-hourly readings from 60,000 sites, monitors contract changes and deals with three settlement runs:

"The settlement runs and the runs we (UKDCS) do to process this, used to take hours in 1993 and 1994. But it is now taking minutes. That is because giga bites of information can be processed in nano seconds and it used to be mega bites in seconds. Technology makes data processing a lot faster. So if people want to process 25 million customers' electronically every day, that is feasible."

(Source: Interviewee: Mike Eggleton, UKDCS)

UKDCS was formed to collect data for the 'over 1MW' business after the 1990 franchise break. At that time each REC appointed a data collector for its business called a Settlement Administration Manager. The settlement administrator who was at that time National Grid Company (later ESIS) appointed UKDCS as the data collection agent as the result of a tendering system. The settlement system has to create a balance at each grid supply point of what has been taken out and what is going into the feeders. This software was called the secondary data collection system. Only recently UKDCS launched a replacement for this called the *Star* system. The *Star* system is more flexible and works with Microsoft software and it gives advanced presentation of readings and formats. The 15-meter operators, 14 PESs, 30 suppliers and Offer interface with the *Star* software.

It is difficult to see that with the experience that UKDCS has built up over the past ten years and the investment which has gone in, that there will be a credible alternative when their franchise comes up for tender in 2000:

"Barriers to entry are high in this business. This is a fifteen million pound business, so there are six or seven million pounds worth of the assets, hardware, software and skills."

(Source: Interviewee: Mike Eggleton, UKDCS)

Barriers to entry may be high for data collection in the 'over 100kW' market but the story is different in the 'under 100kW' market. It is due to be opened up to competition on 1 April 2000 (Offer, 1997). There are already REC metering companies who are offering their services nation-wide for the liberated gas market (see also section 8.3.5).

Most are relying on low technology operations with human meter readers using hand-held terminals (see section 12.4.2). There are concerns expressed here that there has been a lack of co-ordination in the liberalisation of data collection the electricity and gas markets in the UK. The function of data collection from metres in the domestic market was liberalised for gas in 1996. It is argued that this has given the RECs a head start in developing competitive meter reading companies which read both electricity and gas meters at the expense of British Gas. This, along with other issues concerning the co-ordination of the electricity and gas industries in the UK, has led the latest review of regulation of energy supply in the UK to suggest the amalgamation of Offer and Ofgas (the gas regulator).

6.3.6 Prepayment Metering

Customers who pay for their electricity by means of prepayment meters (PPMs) comprise a significant percentage of domestic electricity consumption in the UK. These devices use magnetic card tokens, electronic keys, and more recently, smart cards. Offer takes a view that consumer disconnections should effectively be ended, but that RECs should be allowed to implement ways to ensure that bills are paid in full. Therefore there has been a large growth in prepayment meters and now 1 in 8 domestic customers use this type of meter. The number of annual disconnections has fallen rapidly since March 1990 (when it ran at an annual rate of 80,000): in 1994 the annual rate had dropped to the virtually negligible annual level of 1200. This is undoubtedly an advance, though it does not of course ensure that 'disadvantaged' consumers are able to afford electricity any more than before (Surrey, 1996).

Customers have to pre-pay at charging points for example retail shops or post offices. Rates of repayment are controlled by electricity companies' customers who can if necessary self-disconnect and reconnect themselves. Also, PPMs cost customers more, so a surcharge is imposed in every region in the UK except Hydro-Electric in Scotland.

Properly managed prepayment meters can be a good solution to repaying debt and budgeting electricity consumption. It would also be wrong to equate PPMs with 'disadvantaged' or those experiencing fuel poverty. The majority of the three million electricity PPM customers are not in debt, and have never been. Unlike gas PPMs, in electricity these meters have been promoted as a preferred payment method for all customers:

Vignette XI

"Approval ratings are high because users experience advantages in paying off their debt while remaining on supply. And all PPM consumers have benefited from the real reduction of more than 20 per cent in electricity unit price since privatisation."

(Source: Interviewee: John Heathcock, Schlumberger)

Increasingly these prepayment meters are becoming electronic devices rather than electro-mechanical devices. The electronic meters break down into the Ferranti (now Siemens) card system and the Schlumberger key. Most of the northern companies use the Siemens card and the Southern companies the key. Smart card metering has been a recent introduction. It was initially a response to detect theft but can also be used as a two-way communications device (see section 12.4.5). This means that smart cards have the potential to be incorporated in other home automation systems. Other commentators meanwhile do not see a great prospect of building on, from smart cards to fully electronic metering:

"I don't see an explosion of this. The card system was quite inflexible in that it needed an accounting back-up to check that people were buying cards...These are also very high cost devices and their reliability is less than average. Their certification is about three to four years compared to ten to fifteen for normal meters."

(Source: Interviewee: Alan Dick, Electricity Association)

The latest chapter in the story of prepayment meters are proposals for a levy to help customers who use them. In February 1998 it emerged that the industry is looking to impose a £4 charge to cross subsidise the less well off. Perhaps the crux of the argument comes in the belief by many that costs and management of services are the business of companies, and income for customers on State support is the proper responsibility of Government. Frustrated with the criticism about disconnection for non-payment, the industry has a clear view. If people cannot afford services, they argue, it is the job of the social security system to step in, not for the privatised utilities to wheel out welfare (Garret, 1998).

6.4 SUMMARY

Prior to 1989 and the privatisation and deregulation of the electricity industry, metering played a significantly different role than it does today. The vertically integrated and monopolistic structure allowed integrated resource planning in which the development of the sophisticated electronic meter was at its heart. The key aim of the industry was to maximise the load factor by introducing marginally priced, 'time-of-use', tariffs using meters which could be remotely switched using timeswitches or radio teleswitches. With the unbundling of the generation, transmission, distribution and supply functions, integrated resource planning became impractical. The introduction of this form of *Third Party Access* has thus inhibited the development of this form of metering technology.

Instead of metering being used to facilitate the optimum running of the electricity network through maximising load factor it has been used to facilitate the development of competition (Offer, 1992). The belief is that the rigour of the competitive environment is a more effective way of producing an efficient system. As a result, mandatory half-hourly metering with a communications device has been introduced in the large commercial and industrial market. This has allowed electricity to be traded on an open market, and 'real-time' pricing has been introduced. The down-side is that these devices are costly. So costly that in fact when competition was introduced into the domestic market, electronic metering could not be introduced. A system of profiling was chosen using old electro-mechanical technology rather than half-hourly metering. Despite this the industry is still optimistic that once competition in the domestic market gets bedded down, suppliers will wish to manipulate their generation portfolios in such a way that innovative pricing using advanced metering technology will gradually be introduced.

Profiling may have been a blow to the metering industry but the major bottleneck to the development of universal two-way electronic metering are the plans to liberalise the function of meter operation in 2000. Regional Electricity Companies are fearful that they will lose their franchise to operate meters and will be left with stranded assets. One solution is to hive off the ownership of the meters into a leasing company. However financial leasing is not the core business of electricity companies, and the industry appears rather flat-footed in response to this challenge.

To summarise, the response of innovation in metering technology to deregulation has been spectacular. The emphasis has shifted from using meters for integrated planning to facilitating competition. As a result, 'real-time' pricing is the norm in the industrial market. Nonetheless there are challenges. The introduction of profiling in the domestic and small non-domestic market, has halted the development of 'time-of-use' pricing in that sector for the meantime. Also the liberalisation of meter operations has set the electricity industry a challenge that it is finding difficult to cope with. In time however the industry seems confident that these regulatory forces will define a new generation of meter which will not only be a metrological device but also a customer interface terminal that manages electricity load as well as other services.

CHAPTER 7

CASE STUDY No.2:
ELECTRICITY IN FRANCE

7.1 INTRODUCTION

Picard *et al.* (1985) describes how from 1884 until nationalisation in 1946 electricity in France had developed in a mixed municipal, private and delegated-out format. The delegated-out format usually consisted of publicly owned municipalities who often gave long-term franchises to private companies to develop electricity networks. By the nineteen-thirties plans were being made to co-ordinate collectively the resources, by the State. Most notable was *La Fédération des Collectivés Concédantes* that in 1933 was formed to co-ordinate interdepartmental and inter-company activities. This created the environment for the rural electrification and interconnection. Also a major part of this infrastructure development was *Programme 38,* sometimes called *Le Plan des 3 milliards*, which was laid down by statute in June 1936. It created the *Groupement de l'Electricité* to finance a programme to develop hydro-electric resources for electricity generation, and the interconnection of transmission between isolated networks.

Electricité-Gaz de France (EGF) was set up in 1946 by amalgamating into one nationalised company the municipal and private utilities. Nonetheless there were a few exceptions. Article 23 of the 1946 Act stated that certain municipal undertakings that already existed at the time of the Act, could be excluded from its scope. So for example, at the time of nationalisation, Electricité de Strasbourg applied successfully not to become part of EGF and it has remained independent ever since. Also private companies such as Suez-Lyonnaise des Eaux and Compagnie Générale des Eaux operate some municipally owned electricity operations in certain locations (e.g.

Grenoble and Monaco).[6] The two years in which the electricity and gas administration was combined were difficult ones, and in 1947 EGF was demerged and two separate companies Electricité de France (EdF) and Gaz de France (GdF) were created. Despite the creation of two companies, the distribution, personnel and secretariat functions have remained combined to this day in an organisation known as EdF-GdF Services. This has the advantages of combining the shared services of the two companies but some of the old tensions are still evident, and Jacques Lacoste, a former president of EdF once memorably remarked that:

"It is like an animal with two heads." (Picard *et al.* 1985: ch.9)

In May 1947 Roger Gaspard became Chairman and Chief executive of EdF and set about developing the company into the organisation we know today. Gaspard's system known as *Le Système Gaspard* consisted of close relations with politics. This meant the development of the network through public funding and the development of the principle of electricity as primarily a public service rather than a business device. In ancient societies, explained Gaspard:

"The system did not cater for everyone in society, which was a situation which could only be remedied by nationalisation." (Picard *et al.* 1985: p.42)

This case study will explore the development of *Le Système Gaspard* now known as *Le Modèl EdF* (Wieviorka & Trinh, 1989), and the role that metering technology has played in its evolution in the past twenty years.

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[6] See section 11.2.3 for more details about Suez-Lyonnaise des Eaux and Compagnie Générale des Eaux.

7.2 INFRASTRUCTURE

7.2.1 Regulation

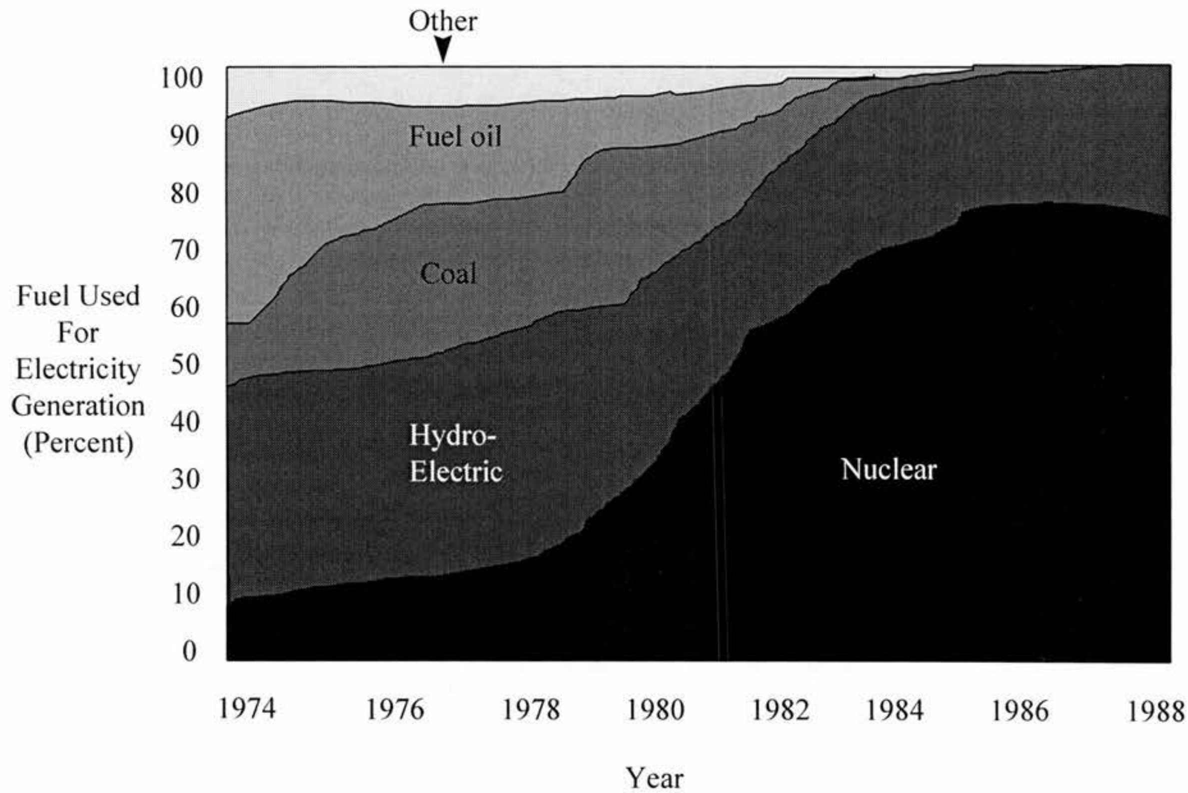
Vignette I

One of the major reasons for the creation of EdF was to co-ordinate and further develop France's hydro-electric resources. Prior to the formation of EdF power was being generated from water sources in the Alps, Pyrenees and The Massive Central. The most important of these was *Compagnie Nationale du Rhône* a gigantic project, begun in 1921 to harness the economic potential of the Rhône basin. Opponents of the hydro-electric power came from two sources. First, the environmentalists who saw the development as: "ravaging our beautiful mountains." Second, the liberal freemarketeers maintained that thermal generation was cheaper and more flexible. However the argument which swayed the case in favour of hydro-electric was the fact that resources of both coal and gas within the national boundaries of France were scarce. This argument has been a continuing theme of energy policy in France ever since.

(Sources: Interviewee: Paul Bongrain, EdF and Picard *et al.* 1985: p.64)

Atomic energy is after hydro-electricity the second grand industrial adventure conducted by EdF. The first nuclear power plant was built at Chinon, in the Loire Valley in 1957 and today eighty per cent of France's electricity demand is supplied by this form of generation (Picard *et al.* 1985: p.207). The nuclear power programme has been dominated by geopolitical rather than commercial logic. In 1948 France became, along with the United States and The United Kingdom and later The Soviet Union and China the first nations to openly have an arsenal of nuclear weapons at its disposal. Also, France is relatively impoverished in indigenous sources of fossil fuels and by 1973 over fifty per cent of electricity produced by EdF came from sources of oil (39 per cent) and Coal (16 per cent) much of which was imported. Events in the Middle East, the world's major oil producer, during the course of that year, conspired to produce a crisis in oil production and exposed France to its dependency on external sources.

Figure 13: A Graph Showing the Changes of Fuel Mix in Electricity Generation in France from 1973 to 1988



Source: Picard *et al.* (1985: p.246)

As a response on 5[th] March 1974 the President of the V[th] Republic Georges Pompidou presented *Le Plan Messer* that intended to wrestle back the control of France's own energy production. At the centre of this strategy was the development of nuclear technology since it largely enabled the production of electricity without relying on external sources (see figure 13). The result of this programme means that it is now self-sufficient in electricity generation and is indeed a net exporter.

EdF is seen as an important ingredient to the success of France domestically as a public resource, and internationally as a means of not being dependent on other nations for energy. Nonetheless, it is argued, EdF is given enough independence from the French State to be run on sound economic principles, which enable it to provide a security of service, which is both safe and competitive. This *Modèl EdF* makes it in the ex chairman of EdF Marcel Boiteux's opinion, the "most Japanese of French companies." (Picard *et al.* 1985: p.165)

Whilst substituting electricity for the direct use of fuels was clearly part of the French nuclear strategy, becoming a major export supplier of electricity was not. Trade built rapidly from 1983 as the output of French plants along the Swiss and German borders was increasingly contracted to foreign utilities. The next major landmark was the completion of the 2,000MW DC link to the UK in 1987. This project was co-financed by the UK CEGB and EdF. The official policy was that trade between the countries would largely balance, with France supplying surplus nuclear electricity when it was available, and the UK supplying at peak times from its coal and oil-fired stations. In reality the flow of electricity has been almost exclusively one way to date (from France to the UK). There were also unsuccessful attempts by German industrial companies, such as BASF, to import power using the transmission lines of their local utility. Whilst these were successfully resisted by the German utilities, the current attempts by the European Commission to introduce mandatory *Third Party Access* (see section 7.2.3) may have been somewhat stimulated by this dispute (McGowan & Thomas, 1992).

By 1989, a number of issues arose which now seem to suggest that the risk-free future that nuclear power promised was indeed an illusion. In particular the coincidence of the uncovering of a generic fault in the steam generators of a number of the 1,300MW units with one of the driest summers and autumns on record caused EdF problems. The dry weather cut deeply into hydro output and meant that EdF had serious problems meeting demand for the autumn months and it had to resort to large-scale imports of power. Also the persistent low oil price since 1986 and decommissioning as well as other environmental costs has led questions to be raised about the efficiency of nuclear generation. Another urgent priority for EdF is to invest in those areas of the system, notably transmission and distribution, which were neglected to carry out the nuclear programme. EdF is aware that, in transmission and distribution, the French electricity supply system falls short of the standards set by other European utilities, and transmission and distribution investment will exceed that of generation for some time to come. The need to invest in international linkages is also becoming pressing, although for rather different reasons. Up to now EdF has been able to build its export trade using existing links which were constructed to improve grid stability and to allow seasonal flows of power to and from hydro-electric producing countries. These lines are now nearing saturation and electricity pylons are not popular, especially in the scenic Pyrenees and Alps, and proposals for new lines will be hard fought.

Perhaps fifteen years ago, McGowan & Thomas (1992) argue that it seemed likely that, EdF could carry through its construction programme to time and cost, without running into major opposition. EdF now knows that this is far from the case. In the medium term, it has to deal with some of the nuclear programme's unexpected consequences, notably a shortage of peaking capacity. In the longer term an important aspect will be decommissioning. Nevertheless, the demise of the nuclear power programme in the rest of Europe has left EdF unfazed. EdF is in no doubt that, all things being equal, nuclear power remains by far the most economic choice.

7.2.2 EdF and The State

Ever since the Enlightenment and the Revolution of 1789 there has been a recognition of the central running of the State for collective interests. Enshrined in this concept is *Le Modèl EdF* combining monopoly, harmony and social consensus. The problem has been to reflect the ever changing social, economic and technological environment in this structure. EdF was intended to optimise the resources, both social and technical to a more egalitarian society. This founding model based on the principles called the *X-Ponts* was seen as the convergence of political, social and the technical dimensions.

Despite this grand vision the reconstruction the French electricity network after the war was almost entirely reliant on aid from the USA. Indeed from 1948 to 1951 eighty to eighty-five per cent of financial investment, in EdF was through *The Marshall Plan* (Picard *et al.* 1985: p.102). Even in 1952 when the Marshall aid ceased there was still large investment, particularly in hydro-electric power in the fifties, and in nuclear in the nineteen-seventies, both of which required State financing. With the withdrawal of American aid, pricing structures also required to be changed, resulting in rates increases which were required to finance the infrastructure development. This financing was, and still is realised through a series of command style plans in which the budgets are made by a joint industry and political collaborating body. It is claimed by the French Treasury that, despite this arrangement, EdF is fully independent, with the Treasury soliciting only "budgetary restraint" and "advice" (Picard *et al.* 1985: p.107).

From the formation of EdF in 1946 up to about 1968 the dominating preoccupation of the Finance Ministry was to keep the price of electricity as low as possible. As a consequence, EdF had the greatest difficulty in balancing its accounts and in finding sufficient revenue to finance an appreciable part of its investments. Consequently a substantial part, about half, of the investments were financed by the State. The large proportion of investment was financed by loans, in which the need to service a growing volume of debt detracted evermore strongly from already small operating margins, reducing still further the possibilities of self-financing, and obliged recourse to further loans (Lucas, 1979).

In 1966 Simon Nora, the inspector of finances published a report on the poor performance of public companies. It proposed an independence for EdF in which it was to maximise both profit and public service, in what was in essence a self-sustaining organisation. This enabled EdF to be founded on sound economic objectives rather than political needs. After the signing of this *Contrat de Programme*, the participation of the State in the financing of the investments of EdF was reduced by the simple expedient of permitting increases in tariffs. This period of increased cash flow led to the financial stability of EdF improving rapidly (Lucas, 1979).

The financial recovery was checked by the first rise in fuel oil prices in 1974, which was not compensated by permission to make a corresponding increase in tariffs. It was not until 1 March 1976, following the permission to increase tariffs by a further fifteen per cent, that it was possible to remove the principal anomalies remaining in the tariffs as a result of the large change in fuel oil prices in 1974. Hardly had EdF managed to obtain permission for this increase in tariffs, when they were struck by a natural calamity. 1976 was the driest year since EdF was formed; the shortfall of hydro-electric power had to be generated from expensive oil (and less expensive coal). Aggravating these factors was the need to finance an ambitious capital-intensive nuclear programme out of a modest cash flow. Nonetheless, since the end of the investment in the nuclear programme in 1982, the French Government has stopped payment to the company (Hooper, 1996).

7.2.3 Competition

As the rest of the world looks to the privatisation and deregulation of its electricity markets, France has shown little interest in opening its market up to competition in electricity production and supply. A Ministry of Industry report by M. Claude Mandil in 1993, has strong views on the matter and calls for competition in Europe, favouring the *Single Buyer Procedure*. The *Single Buyer Procedure* amounts to EdF maintaining its monopoly to transmit, distribute and supply electricity in France, while it buys its generation on the open market. This contrasts with the *Third Party Access* approach where the monopoly distributor must provide non-discriminatory access to third party electricity suppliers. Since EdF generates enough electricity for the whole of France and exports the remainder, the policy clearly would maintain EdF as the sole player in the French market, and a major exporter of generation in Europe.

Vignette II

It is claimed that the *Single Buyer Procedure*:

"recognises the importance of competition, particularly in the production of electricity, where it could constitute an important catalyst for competitiveness."

(Source: Interviewee: Paul Bongrain, EdF)

However, it also sees the need to limit competition both in order to preserve the public interest and enable the implementation of long-term policy.

"a free-market approach endangers social considerations such as the obligation to provide universal services, equal treatment to customers, and the right of the authorities to intervene on the grounds of energy policy...This is the position of the French Government, not EdF. The Government does not seek to persuade others to follow this approach, but to leave them to choose the approach which is most suitable for their country."

(Source: Interviewee: Paul Bongrain, EdF)

In accordance with the principle of subsidiarity, Directive 96/92/EC of the European Parliament on 16 December 1996 came down in favour of both the *Third Party Access* model (Article 17),[7] and the *Single Buyer Procedure* (Article 18) form of regulation. This effectively means that EdF will continue to reign supreme in France, and be a major influence in Europe as a whole for some time to come.

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[7]*Third Party Access* is the system operating in the UK, (see chapter 6).

7.2.4 The *Single Buyer Procedure* in Practice

The problem that EdF has to overcome, is the response to public opinion. Its unwieldy inflexible nature does not react well to sudden mood swings of the public. In the past EdF have acted in principle for 'public welfare' but it does not have a mechanism in which the customer can express choice. Increasingly customers are combining in consumers groups to lobby decisions taken at the centre. In the most extreme critics claim that the world of EdF is becoming increasingly "inhuman" and "Kafkaesque" (Wieviorka & Trinh, 1989: p.135). Another important interaction is with EdF's suppliers. There are a number of companies who rely on EdF's custom for their existence. For example some of the larger ones are Alsthom and Framatome. A strong and reliable EdF is crucially important to these organisations who are significant employers in France.

EdF has also begun actively to encourage foreign and multi-national companies to set up production facilities in France with the lure of cheap electricity. A particularly controversial deal was a joint venture between EdF and Pechiney, which also involved the French Government, to build an aluminium smelter at Dunkirk. Whilst EdF and the French Government have managed to convince the European Commission that the deal does not run counter to Community law, it does involve a risk to EdF. There is clearly the risk that the venture will not be profitable since demand, and hence prices, for aluminium are highly cyclical.

In other markets, EdF's efforts have been less controversial. The policy of aggressively pursuing the space heating market in new dwellings has been successful. About two-thirds of new residences exclusively use off-peak electricity for space heating. This success has been possible because of the comparatively low penetration of natural gas. For existing dwellings, EdF has been less successful. In practice, with low oil prices, most householders find it more economic to use oil throughout the year. Nonetheless, with the space heating demand it has won, EdF has been able to obtain a much greater utilisation on its plants than would otherwise have been the case. It has also made electricity demand highly temperature dependent.

EdF is also expanding into the newly deregulated telecommunications market in France (see chapter 13). A law passed in July 1995 granted EdF the right to offer public telephony services along with the national rail company (SNCF), the motorways and the Parisian transport company (RATP). This makes EdF part of an exclusive group which has a right to develop a national telecommunications infrastructure (Whitehead, 1997a).

7.2.5 Trade Unions

The role of trade unions are also seen as central to EdF and its development, particularly the *Fédération de l'Éclairage* (CGT). The influence of la CGT can be seen in the pioneering personnel relations in the EdF system. There is equality of salaries between men and women and a consultative process between management, unions and the Government Ministry fixes these salaries. The workers' hand is strengthened further by a massive social budget amounting to one per cent of EdF's expenditure, for sports facilities canteens and cultural activities (Picard *et al.* 1985). The CGT still wields a great influence today, particularly with the reliance of French economy on electricity and as a default on EdF. Almost every commercial and non-commercial organisation in France has a connection with EdF since they are the monopoly supplier. Any move towards deregulation or privatisation would inevitably lead to the erosion of the CGT's power, and would therefore be strongly resisted (Whitehead, 1998).

7.2.6 Management

In 1946 many of the electricity managers were hostile to the nationalised model for electricity, in particular the graduates of the large engineering schools. The power of these players rested in their incumbency in the old private and municipal organisations, as well as their engineering and economic skills. It was for this reason that early senior executives in EdF had to have experience of Government work. Pierre Simon, the first President and Roger Gaspard, the first Director General, had both held ministerial posts in the French Government prior to their posts at EdF (Wieviorka & Trinh, 1989).

Vignette III

"Now, however, culture in EdF has become so divorced from commercial reality that it is often described as being as a State within a State ('l'état EdF') not accountable to the people. In the founding model of EdF there was little scope for customer opinion. The anti-nuclear debate is seen as an example of the organisation not being accountable to public opinion. Particular criticism came from environmentalists and left wing intellectuals. Neither did it suit liberal economists who see the programme as not being the most cost effective process."

(Source: Interviewee: Jean Gasc, SLE)

Indeed EdF shows symptoms of bureaucratic regulation (see section 3.4). It is an enterprise with a professional elite with the concentration in one large organisation, where power is delegated from the State. To maintain its credibility EdF has to be seen to passively respond to their customers' and the State's needs. This is not an easy task:

"The staff at EdF should not be seen as structuring society in a type of 'électro-facisme'. What is required is a co-operative network with the external organisations without one actor becoming too dominant. The pressures that face EdF today is responding to the changing social, economic, political and technical environments. The State for example, is not the same today as it was when EdF was created, so how should EdF work with this 'different State'."

(Source: Interviewee: Paul Bongrain, EdF)

7.2.7 The Future

It is suggested that the future model for EdF is through a process 'modernisation' and 'mobilisation', somewhat in the *Paris or French School* of regulation (see section 3.2).

Vignette IV

"Modernisation means the development of suppleness and flexibility in work procedures. This involves debureaucratisation, the introduction of modern technology such as information technology and the changing of working practices. To implement this modernisation there requires to be a mobilisation of all the actors both externally and internally. The challenge is to co-ordinate these forces in a co-operative collective way. The practicalities of this mobilisation involve a collective culture for the common good through 'management stratégique intégré' (integrated strategic management)."

(Source: Interviewee: Paul Bongrain, EdF)

An eighteen-page statement published by EdF on 19th April 1988, signed by the Director General summed up this newly integrated management strategy. "It is necessary to respond to the changing demands combining the harmonisation of decentralisation and the coherence of anticipation and reactivity." Quality is also placed highly on the agenda. "The mark of quality is part of the conviction that the high standards are essential not only in working practices, but also on the interaction of external actors."

7.3 METERING

7.3.1 Strategy

Metering technology is a key player in EdF's future development. Initially introduced to permit new and more complex pricing in industrial metering applications, electronics are now being extended to all electricity metering. The switch from the electro-mechanical induction mechanisms, to electronics is now a relatively inexpensive industrial commonplace for the manufacturers. This change enables new customer interfaces to be developed, for easier and more efficient domestic electrical energy management. The research centres at EdF are preparing the next generations of metering systems, which will support new customer services. These are chiefly in order to facilitate closer relations with the utility and the most efficient use of electrical energy possible. These new services cannot be designed without systematic use of telecommunications resources both outside and inside the home (see section 12.4.1).

To improve their services on offer to the domestic customer, EdF and GdF have launched the ICC project (*Communicating Customer Interface*). Among these new services are automated management of supply contracts and automatic meter reading. Also for distribution, it is hoped that the ICC will provide improvements in: more efficient demand side management; greater internal productivity; and better public image. EdF and GdF are revolutionising the interface concept with the customer by adding communication facilities between the distributor and the customer. The ICC project means to develop a complete communication system utilising power line carrier technology on low voltage link, the public telephone network and radio. In order to manage the new services and the architecture of the ICC system, EdF and GdF have organised the project into three stages. First there are preliminary studies to evaluate the relevancy of developing a new service. Second there is in-situ implementation of thousands of experimental ICCs. Finally there is the definition of the definitive list of services and of the 'target' architecture (*Electricité de France*, 1994).

7.3.2 Pricing

In the fifties EdF started to determine the hydro-electric and thermal generation needs using pioneering mathematical modelling techniques such as linear programming, to optimise the generation and dispatch of electricity. Coupled with this, generation planning was development using a marginal cost pricing structure pioneered by economists at EdF. This was called the *le Note Bleu* and was based on welfare economics. It uses the principle of cost reflective pricing where each consumer group is charged different prices to reflect the actual cost of supply, rather than everyone being charged a flat rate. This in effect made an attempt to mimic the laws of supply and demand in the nationalised monopoly, while maximising consumer and producer surplus.

Vignette V

The necessity for EdF to finance itself brought to prominence a young economist Marcel Boiteux who pioneered marginal cost pricing. Indeed, work done by Boiteux amongst others at EdF during the nineteen-fifties laid the foundation for public utility pricing in particular and monopoly pricing in general for the next forty years. Boiteux sums up the rub of public utility finance as follows:

"One might imagine that the sole difference between the management of a private and public enterprise is that the benefits of the private enterprise go to the capitalist, while in the public enterprise it goes to the State. However it is important to know who is pocketing the money when it is a private individual but when it is the State it does not seem to matter."

(Sources: Interviewee: Paul Bongrain, EdF and Picard *et al.* 1985: p.91)

Marginal cost pricing was introduced to EdF in the nineteen-fifties. *Le Tarif Bleu* is for customers in the 3-36kW band, *Le Tarif Jaune* for customers in the 36-250kW category and *Le Tarif Vert* for customer whose demand is over 250kW. Most consumers are charged on the universal tariff, either with ('double tariff') or without ('simple tariff') a time-of-day rate. Since 1981, the company has significantly broadened its tariff range available to customers and has conducted in-depth modification to its tariff structures (*Electricité de France*, 1993). Due to uncertainties affecting the electrical system, the cost of electricity generation not only depends on the time of day that the electricity is supplied but also on such things as the demand level, and equipment availability. To account for this some 'real-time' pricing options have been introduced. For example, there is the *EJP* option that in effect modulates the price in accordance with 'real-time' system demands. Also as a result of the development of electric heating, power requirements are closely linked to the seasonal cold weather peaks. These peaks in demand are therefore concentrated over a small number of winter days not known in advance. Thus, in the residential sector, the *EJP* option has been further developed, based on the splitting up of the year in 'real-time'. In this option named *tempo*, a year is divided into three types of days: 300 'blue' days (the cheapest), 43 'white' days (medium price) and 22 'red' days (the most expensive). Each day is divided into two periods (nights cheaper than days). The colour of each day is defined only the day before. Customers are encouraged to be equipped with an energy controller in order to program appliance-usage according to the tariff periods and their comfort needs. This sophisticated energy controller enables customers to program with a great accuracy and flexibility their energy consumption according to the prices and the chosen level of inside temperature. The energy management system consists of electronic meter, timeswitch signal box, communications device, *tempo* controller and a *Minitel*.[8] It offers the following services: heating control, time control, tariff control, maximum demand control, remote control of heating by phone, manual override, display of electricity expenses in French Francs and remote reading. Remote measures and surveys in each dwelling allow a very complete feed-back to be obtained. Before adopting this option, EdF conducted an experiment on a sample of 800 customers and found that customers had been on the whole satisfied with this new tariff and had reduced their level of consumption when the price was high. EdF launched the *tempo* tariff option in September 1993 and had the goal to have 300,000 consumers with this option at the end of the year 1996 (*Electricité de France,* 1993; *Electricité de France*, 1995a and *Electricité de France,* 1995b).

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[8] See section 13.3.4 for further details about Minitel.

Up to now at EdF, a specific electronic meter is developed every time it wants to launch a new tariff such as the *EJP*. Therefore it takes between two and three years to develop a new electronic meter, mainly because of the great number of environmental tests the meter has to pass before its acceptance. The main goal of the *Universal Tariff Processing Concept* (UTPC) project is to reduce to a great extent, the time needed to obtain an electronic meter. This research project was launched in 1994 in co-operation with the French company SAGEM and results today in a prototype. The other main goals of this project are to cover many industrial metering needs. This includes functions such as the monitoring of the quality of the power supply or multi-users' metering. It is also considered essential that programming of the meters can be changed remotely, that devices are reusable, that electronic meters based on UTPC principles have at least the same reliability as the current meters, and the cost is about the same as meters installed at present (*Electricité de France*, 1994a).

The introduction of marginal cost pricing was not initially overwhelmingly welcomed when it was first introduced in the nineteen-fifties. Cost reflective pricing meant the customers in remote geographic regions would require to pay more for their electricity and subsidies had to be introduced in some areas such as Brittany, to reflect this. In addition, members of the French Communist Party denounced these tariffs as "contrary to the interests of the working class" as they privileged some individuals over others. The introduction of the *Le Tarif Vert* also preceded the Treaty of Rome and the Common Market in 1957. It therefore reflected the optimisation of French electricity for French industrial needs rather than a European network for European Industrial needs, a fact that is only beginning to be addressed today.

Nevertheless, EdF, most especially since the appointment of Marcel Boiteux to the position of Director General, has practised a policy of relating tariffs to marginal costs. EdF maintains that a properly constructed tariff should not only aim at ensuring the commercial, economic and financial health of the enterprise but, in the case of a public enterprise, should also aim at directing activity towards an economic optimum for the community. There is a large body of economic writing which suggests that in some sense prices set at long-run marginal costs will have the desired effect and will neither encourage waste nor discourage economic application of electricity. Naturally this requirement also excludes the possibility of cross subsidy between sectors or classes of consumers.

The requirement to translate the marginal costs for a specific consumer into tariffs is a complex function of many variables and inevitably leads to compromise. Generally the function is reduced to a formula whereby the customer pays partly according to its maximum demand (in kW) and partly according to the number of units taken (in kWh). The greatest controversy is centred around the tariffs designed to encourage electric space heating in the home and in commerce, the so-called tariffs 'tout électrique'. This was a response in the eighties to the excess in generation capacity caused by the commitment to the nuclear programme. The tariffs require a larger payment for units and a smaller payment for capacity than EdF incurs in buying and operating a nuclear station. If a consumer installs electric heating and EdF meets that increment in load by installing a new slice of nuclear plant, then it appears at first sight as if the costs incurred by EdF bear no relation to those recovered from the consumer by the tariff. Thus the tariff is a long way from reflecting true costs.

In order to reduce the rate of growth of electric heating, *l'Agence pour les Economies de Energie* proposed that an advanced payment should be made by the constructor to EdF for any building that depends on electricity for one-half or more of its heating power. The measure was resisted by EdF as a serious impediment to their domestic marketing, but was supported by the other fuel industries, and especially gas.

7.3.3 Customer Service

One of the policies of EdF is to be engaged on the improvement of the quality of supply. That is why the *EMERAUDE* contract was created in 1992, in association with the representatives of French industry. This contract details quality of supply criteria, and in particular the number of failures (short or long) and the limits of the slow fluctuations of voltage that are acceptable. In case of failure on these criteria, EdF pays for the damage due to the voltage faults. EdF needs a metering device that will be able to measure the quality of the supply according to the criteria given by the *EMERAUDE* contract. Moreover, this device has to be user-friendly enough for the customer, and also has to be read and programmed by remote devices. Therefore EdF is developing a new meter that could measure both consumption and quality of supply (*Electricité de France*, 1995c).

7.3.4 Research and Development

The research and development division of EdF, based at Clamart in the suburbs of Paris, performs theoretical and experimental studies in all areas related to the Company's activities. This includes the design of the future facilities of the generation and transmission system to improve performance and reliability, and reduce the impact of existing facilities on the environment.

In parallel with the development of a new generation of electronic meters based on a new architecture, the research and development division of EdF is developing an open-ended modular testing bench for electronic meters. This allows rapid incorporation of changes and modifications for testing new appliances, with integration of specific functions as necessary. The support bench is thus a test platform for metering equipment, designed on a modular basis in order to act as a support for specific applications. The bench has a set of standard functions adaptable to the testing of different types of meters. The first generation domestic electronic meters have brought reassuring test results. In a period of three and a half years, when about a hundred thousand meters have been installed, the real failure rate is less than 0.3 per cent. Furthermore, a significant number of these failures came from mechanical and not electronic pieces of equipment (*Electricité de France*, 1995d).

Vignette VI

"Utilities in the Continent are much more protective of their manufacturing base. Utilities in those countries will not import new technology and will only embrace it when manufacturers in their country are capable of producing it... The French electricity market is still being driven by technology. Still investing in very sophisticated and complex metering so as to manage the load profile."

(Source: Interviewee: Brian Bates, AMPY)

In effect, metering technology is being developed to make the present system of vertically integrated electricity supply run more efficiently.

7.3.5 Standards and Protocols

There are two main trends in the field of electronic metering in the nineteen-nineties. Firstly, devices are becoming very sophisticated allowing more and more parameters to be measured, computed and stored. Secondly, transmission media are now used in metering (e.g. the Public Switched Telephone Network, the Integrated Service Digital Network, the power line carrier systems, a wide variety of field buses, the X25 network, etc.). Thus, the challenge is now to ensure that a complete interconnection is possible between all equipment resources, based on a coherent and global architecture. The traditional protocols are clearly limited because they can transport only bits of data without considering the problems raised by the complexity of telecommunications structures. For this reason, EdF's research and development division, in association with a manufacturer, has initiated a project aimed at specifying a general model of an application layer description that is less complex than the standardised MMS (Manufacturing Message Specification) model. The result is a simple model called DLMS (Distribution Line Message Specification), which is sufficiently extensive for remote reading and network automation. DLMS is now considered a standard from the IEC's (International Electrotechnical Commission) point of view. The main interest of DLMS is to ensure complete independence between the world of applications,[9] the protocols and media that may be used. DLMS offers a high-level interface based on the notion of service, which covers all needs for remote meter reading and remote control. For example, standardised services offer very easy ways to read and write variables, to start and stop processes, to down-load new applications or to manage access rights on objects. To illustrate these capabilities, EdF has developed two architectures in accordance with DLMS: the PLAN (Power Line Automation Network) architecture, based on a power line carrier system and the TRIM+ protocol on the traditional phone network. Both are now under discussion in IEC meetings aimed at standardisation. EdF is now designing complex architectures that integrate both PLAN and TRIM+ (*Electricité de France*, 1996).

7.4 SUMMARY

The route that France is taking with respect to the regulation of electricity is by means of a vertically integrated nationalised network. Through its promotion of the *Single Buyer Procedure* it wishes to retain EdF as a national champion but also a strong player on the European and international electricity markets. EdF is well aware that it has to adapt to the changing economic, social and technical environment. It sees this can be achieved through a process of 'modernisation' and 'mobilisation'. A key role in this process is given to technology. Nuclear technology enabled France to become self-

[9] All metering applications both fluid or electrical.

sufficient and even an exporter of electrical power during the nineteen-eighties. This strategy has been complemented by the development of sophisticated metering that has allowed the introduction of cost reflective pricing mechanisms. In this way metering technology is being used to make the system more efficient by increasing the load factor. This in turn is being used to justify the integrity of the vertically integrated monopolistic framework. It also places EdF in a strong position in developing standard protocols for metering technology such as DLMS. EdF is the largest electricity utility in the world with a strong research and development division. This gives it a powerful presence in European and on international technical committees. Indeed EdF's international expansion plans have been compared with Napoleon Bonaparte's ambitions for the *First Empire* (Whitehead, 1998). On the downside, it is suggested EdF operates remotely from the disciplines of the market and has been seen by some as a 'State working within a State' which is detached from its customers.

CHAPTER 8

CASE STUDY No.3:

GAS IN THE UK

8.1 INTRODUCTION

In 1792 William Murdoch, an inventor and entrepreneur, ignited the gas revolution in the United Kingdom by using gas lights at his home in Redruth, Cornwall (Peebles, 1992: p.8). By 1812 the UK had the World's first commercial gas works, and in 1830 the number of gas undertakings in the UK had grown to some 200. The Gas Act of 1948 then amalgamated and nationalised all the private and municipal gas companies (now numbering 1,046) operating in the UK. This resulted in the creation of 12 Regional Gas Boards and the formation of the Gas Council. At this time, production largely involved the high cost process of manufacturing from coal. It was not until after the award of licences for exploration, under the Continental Shelf Act 1964, when substantial reserves of gas were discovered in the UK portion of the North Sea, that the gas industry in the UK received a second wind. Since this time natural gas has been steadily introduced for heating, cooking, industrial process and more recently, power generation purposes. Changing the existing method of operations required the conversion of gas appliances throughout the UK, enabling them to burn natural gas. It also necessitated the construction of additional gas terminals on the East coast, and a high pressure transmission system for transporting supplies to the Regional Boards. The rapid development in the exploration and production of gas had a similar impact on the structural elements of the transmission and supply of gas, requiring amendments to the organisational structure of the gas industry. Under statutory guidelines in the Gas Act of 1972 the Gas Council was renamed the British Gas Corporation and assumed control of the 12 Area Boards. The British Gas Corporation continued to enjoy monopoly rights over the sale of gas and was extended monopsony powers with respect to any gas reserves from the UK's sector of the North Sea (Cameron, 1995).

The introduction of natural gas has substantially increased the demand for gas. The demand for gas more than doubled between the years of initial conversion operations in 1967, and the oil price shocks of 1973 and 1979. In fact the oil price increases of 1973 were a contributory factor in raising the demand for gas in the commercial, industrial and domestic markets. In the interim, further gas deposits were discovered in the North Sea, Irish Sea, and more recently West of Shetland, and input terminals were added to the transmission network at Easington, Barrow-in-Furness and St. Fergus (Peebles, 1980). This development of the natural gas industry in the UK must be considered a magnificent achievement and was delivered through a vertically integrated market. This case study will consider developments in the gas industry in Great Britain (not Northern Ireland) since 1979. The town gas industry in Northern Ireland collapsed in 1984 and the fledgling natural gas industry has yet to take off in the Province following the construction of an interconnector from Scotland in 1996 (Ofgas, 1997).

8.2 INFRASTRUCTURE

8.2.1 Privatisation

In May 1985 the Government announced its intention to privatise the British Gas Corporation (BGC). Under provisions made in The Gas Act (1986), the businesses of the BGC were vested in British Gas plc (BG) (Barnett, 1996). British gas was then offered for public sale in December 1986. In terms of structural reform, no provisions were made in the legislation for industry restructuring, and BG was sold as a vertically integrated concern. 12 quasi-autonomous regions operated the supply arm of the business, though the purchase, transmission and storage activities were co-ordinated centrally. Although no restructuring took place, the Gas Act 1986 did legislate for the introduction of competition, though in practice it added little to the Oil and Gas Enterprise Act (1982). Previously, the Act had allowed for access to the gas transmission network by introducing common carriage for potential gas competitors and the requirement that any gas be offered for sale to BG, ceased. The Act also legislated for the disposal of BG's offshore assets, which were vested in the new company, Enterprise Oil (Cameron, 1995).

British Gas plc (BG) was privatised with a monopoly licence to supply gas to all customers below 25,000 therms in Britain. It also retained control over the mains network of gas transportation and storage facilities. The company was required to offer customers a fixed tariff and not to show any undue preference in the setting of the tariff. The argument put forward for retaining a vertically integrated monopoly was that British Gas needed the scale and the size in order to engage with international competitors. As supplies of natural gas became scarce, companies would have to compete for the remaining gas fields. Competition for such fields would be on an international basis and therefore BG would need to be as large as the State-owned monopolies of other countries in order to compete effectively (O'Neill, 1996).

The privatisation of British Gas in 1986 led to the establishment of a complex regulatory framework based largely upon a licensing system. The Government supervisory body is the Department of Trade and Industry (DTI). In addition, a regulator for the gas industry was established, (the Director General of Gas Supply, DGGS) who heads the industry watchdog Ofgas (Office of Gas Supply). The Monopolies and Merger Commission (MMC) support Ofgas in this role. The MMC's responsibility is clearly prescribed by statute. It is required to make recommendations on licence modifications where the Director General and licensee fail to reach agreement (Cameron, 1995 and O'Neill, 1996).

Ofgas' function covers economic and to a lesser extent social matters. It currently monitors the activities of the public suppliers of gas and, where necessary, to enforce compliance with important requirements of the Gas Act affecting such suppliers. Other functions include keeping under review the carrying on, both within and also outside Great Britain, of activities connected with the supply of gas through pipes, and collecting information with respect to such supply. Ofgas is also responsible for a much wider range of activities, reflecting the new licensing régimes including; the issuing of licences and monitoring of levels of service which BG and other gas companies provide to their customers (Cameron, 1995 and O'Neill, 1996).

The Government, through the Secretary of State for Trade and Industry, retains only a few functions in day-to-day regulation of gas supply, chiefly the granting of authorisations to supply, testing meters, and checking gas quality and overseeing competition law. The Department of Employment is concerned with making, and the Health and Safety executive with enforcing, safety regulation. At present, BG has a statutory obligation under the Gas Acts to provide a 24-hour emergency response service to handle gas leaks at premises which it supplies with gas, in order to deal with threats to public safety (Cameron, 1995 and O'Neill, 1996).

The Gas Consumers Council (GCC), is an independent body whose function is the investigation of complaints from both tariff and contract customers. In the event that they are not resolved, either at regional or national level, they can be referred to the Office of Fair Trading (OFT), if they relate to contract matters, or to Ofgas, if they relate to tariff matters (Cameron, 1995 and O'Neill, 1996).

Since privatisation in 1986, BG has been subject to a number of Monopolies and Mergers Commission (MMC) reports and an investigative review by the Office of Fair Trading. The first of the MMC references in 1988 concerned lack of transparency in BG's pricing structures. The result of this was a requirement for BG to publish price and tariff schedules to ensure that BG did not engage in discriminatory pricing. Despite the MMC recommendations in 1988 competition was relatively slow to develop. Only the larger oil companies emerged as potential competitors in the gas contract market. An Office of Fair trading report in October 1991 made several further recommendations including an undertaking of BG to relinquish sixty per cent of the gas contracts market and separate its transportation and storage operations from all other BG activities. The need for BG to restructure its business was then reaffirmed in December 1993 in a MMC review, requested by BG. It felt that regulatory developments since privatisation were creating uncertainty and was impeding the ability of BG to carry out its business effectively. The Gas Act (1995) followed shortly after these reviews. In order for the licences to comply with the new licensing framework set out in the Gas Act (1995), any transportation activities must be distinctly separate from those of supply. BG proposed a 'transfer scheme' in accordance with the requirements of the Act. The 'transfer scheme' involved the creation of a subsidiary company, called Centrica, to which the bulk of supply and trading assets and liabilities were transferred. The 'transfer scheme' took effect in March 1996. Under the demerger proposals, Centrica assumed control of all of BG's trading property and businesses and also the Morecambe Bay gas fields. Also vested in the subsidiary company is BG's interest in Accord Energy Ltd, an energy trading company. The transportation and storage businesses are now the responsibility of TransCo International. In addition, TransCo International has more wide-ranging subsidiaries including exploration and production, global activities and power generation (Cameron, 1995 and O'Neill, 1996).

Vignette I

"The structure and people which has made a success of the company in one era is no longer the structure or people which make it a success in the next era... The gas industry in the UK started in private hands and then came together when the British Gas Corporation was set up as a national objective, to harness natural gas for the benefit of the country. Now I think that was absolutely the right way to do it. It was centrally planned and directed and has indisputably created a network which has benefited the country immensely. But I think the system evolves, the pipeline system is there, it has stood us in good stead, but access of it is now being opened up to let others use it with a payment of a fee to TransCo."

(Source: Interviewee: Alan Curran, Ofgas)

8.2.2 Production

The extraction and production of natural gas is conducted mainly by the larger oil and gas companies, sometimes in partnership with BG. Initial consortiums between BG and various oil producers were further empowered by Government policy at the time. Policy dictated that any discoveries of natural gas were to be offered for sale to BG. This situation changed following primary legislation in the Oil and Gas Enterprise Act (1982). Further moves to end BG's monopsony included MMC recommendations in its gas report in 1988, disallowing BG from contracting for more than ninety per cent of any new gas field. Among the companies that supply gas in Great Britain are oil companies such as Amoco, Conoco, Mobil, Texaco, Shell, Elf, Total, Amarada Hess, Esso and BP, to name but a few (Barnett, 1995).

In order to cope with peak demands in the winter months, gas is balanced from supplies of liquefied natural gas and gas stored in underground reservoirs, by line packing, or in tanks adjacent to the network. These type of storage facilities also provide gas in the case of a disruption of supply due to plan failure or emergency. Rough is the largest of BG's storage facilities and is a former gas field that has been redeveloped as a seasonal store for gas in the North Sea. Also load is managed by offering large customers interruptible gas contracts so that they switch energy supply (usually fuel oil) during times of peak demand on the system.

8.2.3 Transmission and Distribution

Following the extraction and production process, the gas is fed into various beach head terminals and thereafter fed into the national transmission system (NTS) at high pressure. Prior to final resale, the gas then passes through differing levels of the regional distribution networks (now known as Local Distribution Zones, LDZ) at increasingly reduced pressures.

Of all the stages in the natural gas chain, only transmission and distribution are now considered natural monopolies. As with all the utilities that operate a network, once the network is constructed (usually at very high cost) the costs are sunk and the infrastructure effectively has no resale value. It is therefore inefficient to develop alternative networks. A transportation price control formula (RPI-X)[10] has been introduced to limit the overall revenue obtained by BG's transport and storage business, TransCo (see Barnett, 1995; Cameron, 1995 and O'Neill, 1996).

8.2.4 Supply

For the retail supplier there are few fixed assets. The only requirement for retail suppliers is to organise contracts with the producers and the customers. Therefore, barriers to entry (or exit from) the retail supply market are low, competition is largely on price, with any differentiation consisting merely of financial arrangements in the terms of the contract. Centrica is BG's supply arm.

Vignette II

"People who have a background in financial service type companies are being appointed by Centrica. This causes a problem for the regulator because the people who are running these companies have a red-blooded commercial approach. Gas supply is a financial services operation, and to emphasise this Centrica have produced the *Goldfish* card, which a loyalty card and a credit card at the same time."

(Source: Interviewee: Alan Curran, Ofgas)

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[10] See section 4.4.4 for a fuller explanation of RPI-X

The UK gas supply market is split into three main sectors, industrial, commercial and domestic. Legislation in the Gas Act (1986) defined the various sectors of the market as being based on the volume of gas demanded. The industrial market consists of some 76,000 customers and consists of about 25% of sales volume. For these consumers whose consumption exceeded 25,000 therms annually, the market was open to competition at the time of BG's flotation. The franchise market was reduced in 1992 to customers demanding more than 2,500 therms annually. This sector comprises many of the commercial customers, generally classified as hotels, schools, hospitals, offices etc. and accounts for about 18% of the market by volume. The domestic consumer market comprises over 18 million customers and was gradually opened up to competition during 1997 and 1998. Since the non-domestic market was opened up, BG's share has been falling dramatically. Competitors have been 'cherry picking' the market and have focused on high load contracts. Price schedules were also introduced to the non-domestic market to prevent BG from using a predatory policy to keep new entrants out of the gas supply market. Since BG had to publish its prices for all industrial and commercial users, competitors knew exactly what contractual terms they had to offer in order to win business. This policy allowed competitors to win eighty per cent of the large firm (not interruptible) business. The power station market has also emerged since 1990 and has been competitive. Although BG is the largest single supplier, it has never had the dominant position that it has enjoyed elsewhere in the gas industry (Ofgas, 1997).

In order to extend the level of competition further, with a view to full competition in the domestic market, the Gas Act of November 1995 provided for various supply activities to be authorised separately. The Act created three classes of licensed activities. *Public Gas Transporters* who are concerned with the operation of pipeline systems for the transportation of gas. They convey or store gas from the terminal to the meter, or possibly from or to other public gas transporters in arrangements with shippers. *Shippers* are concerned with arranging for gas to be transported, normally from beach terminals through the public transporter pipeline system. They also sell gas to suppliers. *Suppliers* are concerned with the direct sale of gas to the consumer and act as the first point of contact for the consumer. To circumvent some of the problems involved in storage, shippers also offer interruptible contracts. In return for securing a lower unit price, customers are prepared to have their supply interrupted during periods of peak demand.

There are four main categories of competitors in the marketing of gas. First, gas producers which also ship such as Alliance Gas (BP, Statoil and Norsk Hydro), Quadrant Gas (Shell and Exxon), Kinetica (Conoco and PowerGen), Neste Production Ltd (a Finnish company trading with Northern Electric), Agas (Elf Aquitaine), Mobil Gas and Amerada Hess (trading with Scottish Hydro-Electric). Second, Regional Electricity Companies: all 12 RECs in England and Wales have established gas marketing arms, as has ScottishPower. Third, specialist fuel distributors who were strong in the LPG market prior to privatisation such as British Fuels, Flogas and Calor. Finally, there are independent brokers of gas such as United gas and Bell gas (see O'Neill, 1996 for more details).

8.2.5 The Network Code

The rapid development of gas competition has necessitated the introduction of a set of business rules to act as a foundation for the exchange of contracts required for the transportation of gas (O'Neill, 1996). The rules are embodied in the Network Code which outline the rights and responsibilities of companies involved in the transmission of gas. The Network Code was implemented in 1996 and its purpose is to allow gas shippers open and non-discriminatory access to the gas pipeline and storage system operated by TransCo. It also details the obligations of TransCo in providing a transportation service to its customers. The Code is essentially a framework of contracts that act as guidelines for shippers utilising the transportation network and seeks to establish access on an equal and transparent basis.

The main principle underlying the creation of the Network Code, is the requirement for operational balancing. Shippers are encouraged to balance their supplies and demands on a daily basis. If demand rises above that being supplied by a designated shipper, TransCo imposes a charge for the extra gas used. Alternatively, if a shipper inputs more gas than is necessary to meet demand, then a payment is received from TransCo. This is referred to as the flexibility mechanism. A trading system is crucial to the procedure by which TransCo maintains records of every gas consumer. It indicates which shipper is supplying gas, the volume of the gas being transported and for which supply site the gas is intended. Each meter point has a unique reference number, the 'M' number. This number and the relevant postcode enables TransCo to charge shippers correctly for transporting gas to each and every supply point. It also covers the process of transferring customers from one shipper/supplier to another. TransCo is also subject to a range of standards in the areas of supply which include supply point transactions, meter readings and data-loggers. TransCo's performance against these standards is monitored regularly and reported to both Ofgas and the shippers. If TransCo falls below the standards set, it becomes liable to provide compensation to the affected shippers (O'Neill, 1996).

Vignette III

A suite of computers systems (*UK-Link*) has been developed by TransCo to support the Network Code. *UK-Link* has continuously updated in consultation with the industry. The Network Code has opened the possibility of a spot market for gas but it is thought unlikely to develop in the near future:

"There has been an active one (spot market) in North America for many years, but in North America the sources of supply are different. They are more numerous on land, and they tend to be pure gas fields unlike what is found in the North Sea (which are often gas, condensates and oil together). In the North Sea the take off is restricted by the oil extraction, so you cannot manipulate the swing (load factor) as easily. In the UK there has always been a distinction in contracts between base load contracts, peak shaving and ones in between, in terms of matching supply with demand. One way in which a UK spot market could

develop however is through the rules of the Network Code. There are significant financial penalties if a shipper fails to deliver gas into the system when the shipper said it would, on a 24 hour basis. The spot market will be there in putting producers in touch with suppliers on an instant basis. So if a shipper has seriously underestimated its demand, instead of defaulting in its obligations in the Network Code it can then go to a producer, and at a price, obtain gas."

(Source: Interviewee: Alan Curran, Ofgas)

8.3 METERING

8.3.1 Metering Technology

Samuel Clegg took out the first known patent for a wet gas meter in 1815, but records indicate that metering of gas did not come into general application in the UK until the 1830s. The original meters had a rotating drum operating in a bath of water. These caused problems, because water could freeze during the colder months of the year, or because the water evaporated. But by around 1850, dry meters devised by John Malam (1820), Miles Berry (1833) and Alexander Wright (1844) were introduced and these remain the basis of the type of meter in general use today. The introduction of prepayment meters in the UK, patented by T.S. Lacey in 1870, took place towards the end of the century (Peebles, 1980). This was an interesting development in that it helped to spread the use of gas to the less wealthy sections of the community. Gas metering technology remained relatively unchanged for the next hundred years until recent changes caused by developments in the areas of micro-electronics and ultrasonics. Thus today the role of the gas meter has changed from a cash register where you want meters read and bills sent out as efficiently as possible, to an instrument which can manage and monitor load.

CEN TC294 sets out the user requirements for gas metering technology in the UK in document reference WG1/N65E of the European Union. This document has tables on applications with generic headings concerning functions and performance requirements. It also goes further in setting other requirements covering economic considerations, standards, communication systems, integrity, security, privacy, confidentiality and power supply. It also separates out response time, throughput, priority requirements and defines data formats for common variables.

8.3.2 Pricing

The domestic supply market in the past was based on the concept of universal service at equal price. One of the major worries for Ofgas is that as competition develops prices will then vary across the country. In general, those areas which are far away from the beach-head (where gas is delivered by producers to TransCo) will be forced to pay higher prices than these near the beach-head. Although the introduction of competition has reduced overall supply prices, it will also be introducing pricing inequality across the country as BG's traditional structure of cross-subsidies is unwound. This means that the new entrants to the market will target ('cherry pick') customers close to the beach head first. This could put BG in the situation where it is left with only the less profitable customers, either those in higher-cost geographical locations or those previously subsidised (bad debt) customers.

Vignette IV

Nonetheless there is almost an evangelical zeal to the privatisation of the gas industry in the UK:

"Britain leads the way with gas prices, we have the lowest gas prices in the world, ahead of even North America. Now some of that is down to competition and the opening of the UK gas market. That is of enormous competitive benefit for British industry. I think that is where pressure will ultimately come to bear, it is certainly, happening in Germany and will happen in France. Companies like Air France are in the third division compared with British Airways and are costing the French taxpayer a great deal of money. This is not technology, it is political will to open up markets. Just as a number of years ago it was not the market which regulated

the gas industry it was the Treasury which set gas prices according to the Government needs."

(Source: Interviewee: Alan Curran, Ofgas)

This optimistic picture belies some problems. British Gas has been damaged by its commitment to high-priced 'take-or-pay' contracts to buy gas in the North Sea. This is a key factor in allowing the new market entrants to undercut BG's prices by large margins, because the price of gas has fallen since the 'take-or-pay' contracts were signed. These contracts are estimated to be worth at least forty billion pounds over the next twenty-five years. Although there have been suggestions that BG finds itself in this situation due to mismanagement and lack of foresight, the company blames the Government and the regulator in misleading it over the pace of market liberalisation. Moreover, a number of these contracts date from before privatisation, and were therefore agreed under very different market conditions (Barnett, 1995).

The tariff charge in the UK comprises a fixed element, the standing charge, and a commodity charge that applies to differing levels of consumption. The commodity charge reduces as demand moves progressively to higher levels of consumption. Earlier differences in standing charge to reflect regional factors, have been replaced by a single national charge, and in October 1991 it was altered from a quarterly, to a daily rate. Commodity rates have also altered. Previously a single commodity rate applied across all consumption levels, but in March 1990 a lower charge was introduced for consumers above the 15,000 therm level. In April of the following year, the commodity charges were further tiered to reflect demand levels. Different tariffs were offered to consumers within specific consumption bands, with the thresholds set at 5000, 10,000 and 15,000 therms a year respectively. The distinction in tariffs, and corresponding demand levels is however being eroded, following the influx of competition in the gas market (Ofgas, 1989).

The two elements of the tariff, the fixed and commodity charge, are designed to cover the various costs involved in supplying gas. The standing charge contributes only to the fixed costs in the provision of a gas supply, such as meter reading, customer accounting and pipe or meter maintenance. The commodity charge contributes primarily toward gas purchase costs, transportation and the costs of storage facilities.

Vignette V

Despite the strong seasonal factors that influence the demand for gas, seasonal tariffs or any form of promotional tariff have not generally been a strong feature of operating policy and tariff structures:

"Apart from interruptible contracts for very large customers, I do not see that ('time-of-use' pricing) happening in gas. In a 24 hour cycle the gas is packed in the pipes so there is not such a same sensitivity to the timescales as in electricity. So there is a certain lag for gas in contrast to electricity which is instantaneous."

(Source: Interviewee: John Heathcock, Schlumberger)

Although there is no plan for extensive 'time-of-use' pricing in gas, there has been an introduction of different payment mechanisms with the introduction of the DirectPay, and more recently, the OptionPay tariff. They allow customers to pay their accounts monthly by variable direct debit at a discount. Around one quarter of domestic customers pay in this fashion.

8.3.3 Electronic Metering

During the early nineteen-eighties, BG was involved in a mains-borne (power line carrier) field trial with both water and electricity utilities. The project was the first major automated meter reading field trial in the UK involving all three major utility industries. At the time, it was felt that a single unit collecting data from three meters would be more cost effective than individual home units or separate systems. Much effort was put in to ensure that valuable data, in terms of response time and availability, were collected on the performance of the medium chosen. BG took a central role in data analysis and reporting for the trial, and utilised BG's *Viewdata* system, which was available to all parties involved for fault reporting. The trial identified some areas for development, such as the need for repeaters for collecting data from houses at the extremities of the distribution cabling, and such issues as network management and data collection for larger installation bases. Time during and following the trial was used to refine the perceived industry requirements for a remote meter reading system. These included the data that was to be collected, and fast response time required for detection of gas theft (*British Standards Institute*, 1998).

Also during the mid nineteen-eighties BG participated as an observer on trials of 'no-ring-trunk' technology called CALMS. This allowed access to two dummy gas loads and basic data communication to twenty-five homes on the trial. Data acquisition software allowed direct comparison of communications system performance with mains-borne system. A follow-on project involving the British Telecom (BT) *BitStream* system allowed BG to further develop ideas for data management within the home unit, for an automated meter reading system. In collaboration with SEEBOARD (a REC) and Mullard, BG worked on the specification for gas requirements, for both long-term aims and short-term service evaluation. When BT decided to stop its own development work on *BitStream* the project terminated (*British Standards Institute*, 1998).

Following these trials, the utility industries faced changes associated with privatisation and BG's effort diminished as other options were pursued. BG became more interested in having access to its own automated meter reading system for gas metering alone, not relying on third party data communication channels. In 1993/4 British Gas was involved in a radio-based remote meter reading field trial initially involving 1000 'R5' pulsed output meters. The system was hierarchical and multi-layered, with a one-way in-bound radio communications device at the meter level. It transmitted the consumption value and tamper status to a second level concentrator unit, on a pseudo random basis to avoid collisions with its neighbours, four times a day. The transmitter used a 50MHz carrier with an effective radiated power rating of 10mW. The baud rate between levels was 1200bps and the data-link protocol used was an X-25 hybrid. At the concentrator, the meter data was time-stamped and stored, and then up-loaded on request to a third layer controller device using two-way radio communications. From the controller to the host user, the communications path used was the PSTN. Following the large-scale changes occurring within UK Gas during the early to mid-nineties priorities changed, and the technology was not developed further. Consequently, the equipment was decommissioned in early 1995 (*British Standards Institute*, 1998).

In 1994 TransCo in collaboration with Gaz de France and others developed a management information system for recording operational field data read locally from 'E6', or ultrasonic, gas meters. The system, called *E6 Diagnostic Data Interface* or EDDI, consisted of a portable hand-held reader, or Diagnostic Data Reader (DDR), and a system controller/database, which ran on a stand-alone PC, located in a TransCo district office. An EDDI controller supported up to 20 DDRs, which in turn could record data from up to 100 meters. The EDDI system worked by firstly entering an alpha character, called E6 'flag', recorded from a meter's LCD during a billing cycle meter read, and the customer's details into the database's customer list. Details of up to 100 E6 meters were then selected and down-loaded to a DDR along with an encrypted version of the DDR's application program and specific security details regarding restrictions on the DDR's usage. The DDR communicated serially with a meter through the industry standard optical port and probe interface, conforming to the BS EN 61107 protocol. Its applications software was designed to interface with all E6 meters purchased by TransCo. To date two protocols have been supported; one utilises the 'C' programming mode of BS EN 61107, the other proprietary protocol was developed specifically for the E6 meter to minimise communications power requirements. Both incorporate similar asynchronous meter 'wake-up' sequences which essentially ensure DDR/meter communications are synchronous with the meter's natural cycling periods. A DDR reads, and records, typically 60 of the meter's operational parameters. Captured data are immediately analysed and summary reports are displayed for appropriate section by operational staff in the field. There is full reporting via the EDDI database, which incorporates customised reports for use by TransCo special gas investigators to collate data on suspected meter tampering trends (*British Standards Institute*, 1998).

Presently the system has been installed in TransCo districts for use by metering operational staff and by BG's gas research and technology centre to support an Ofgas requirement to monitor the first 15,000 production meters in the field. More recently, a hybrid system has also been developed for use in TransCo Area East's Hertford Laboratory to record all E6 meters returned from the field installations (Ofgas, 1997).

8.3.4 Prepayment Metering

Under the terms of their licences, suppliers must offer domestic customers the option of a prepayment meter prior to disconnecting them for failing to pay their accounts. Just under a million domestic gas customers utilise a prepayment metering device and up until recently were traditionally coin and token operated.

Vignette VI

***Quantum* metering, a two way electronic system for prepayment using smart cards, was introduced by BG in the late nineteen-eighties and early nineties. This enabled the utility to re-set tariffs and extend customer credit electronically:**

"It was put into place by BG in its previous all-seeing all-knowing form... Under the old system the monopoly could push the technology and this approach has been questioned in the new deregulated market. It was a wonderful system, the type of system that British Gas would go for when they had all of the market, but this type of system is not particularly appropriate in a competitive market... One of the problems is that *Quantum* is expensive, very very expensive... What we are looking for just now is not technology push, but market need. What we have at the moment is *Quantum* as a very expensive blocker and what we would like to see

is all the new suppliers coming out with their own innovative solutions to these problems."

(Source: Interviewee: Alan Curran, Ofgas)

In order to provide this in the first phase of domestic competition, the *Quantum* system run by TransCo was modified to allow suppliers to use it. Processing of *Quantum* transactions has been centralised in Newcastle-upon-Tyne in one office, which has secure arrangements to prevent Centrica gaining access to details of *Quantum* transactions carried out by the customers of other suppliers. This arrangement appears to have worked satisfactorily for the first phase of domestic competition, but may need revision as competition begins to take hold.

8.3.5 The Liberalisation of Meter Operation and Data Collection

Until 1996 BG had been responsible for all gas metering. During that year Ofgas established a framework to allow competition in meter reading and meter provision installation.

Vignette VII

"The metering side is overdue for some innovative solutions, and I think it will be a 'big player' who will make an impact e.g. Siemens or Schlumberger. Metering has been a secondary matter certainly from the gas perspective. In the past it has been dominated by British Gas and a few large metering companies, who did not compete but relied on British Gas for its annual order. That is not a recipe for innovation or new solutions, that made things very static."

(Source: Interviewee: Alan Curran, Ofgas)

Ofgas' Competitive Metering Steering Group (CMSG) brings together experts and interested parties from a variety of different backgrounds to consider issues associated with competition in metering. Organisations include the Council of Registered Gas

Installers (CORGI), the Institution of Gas Engineers (IGE), the Gas consumers Council (GCC) and other customer groups, meter manufacturers, shippers, suppliers, public gas transporters and companies able to offer alternative meter reading or installation services. In October 1996 meter reading was opened up to competition. By December 1996, some 23 meter reading companies had registered with Ofgas (Ofgas, 1997).

Vignette VIII

One example of how the future may develop is highlighted by British Gas' activities in data collection. When British Gas separated its trading businesses from TransCo, TransCo had the responsibility for gas meter reading, but it used as its agent British Gas' own meter readers, who were employed by its gas supply arm, now known as Centrica. This situation was unsatisfactory, as it resulted in Centrica reading the meters for competitors' customers.

Centrica proposed that it set up a joint venture meter reading company with another party, in which BG would be a minority shareholder. BG's prospective partner, Group 4, was identified following a competitive tendering exercise. Ofgas consulted on its proposal and the industry generally accepted that the joint venture option should be pursued. On 14 October 1996, the joint venture, known as AccuRead, became operative.

While AccuRead initially provided TransCo's meter reading service, this business has been progressively opened to competitive tender. The first of these tenders, for TransCo's industrial and commercial meter reading service in the North-Eastern and Northern metering zones, was awarded in November 1996 to Northern Metering Services Ltd. an agency company of Northern Electric (a REC). Other meter reading suppliers now in the market include Lowri-Beck (the only independent competitor) and subsidiaries of utilities such as Energy Communications Services (London Electricity) and East Midlands Electricity

Metering Services.

"What you are seeing is regulatory pressure on efficiency coming to bear, and this has caused the gas industry to come up with structural innovations. They are looking at the costs closely, which has meant a move to the out-sourcing of activities. Subcontractors can do the work at a lower cost than the utilities themselves. They have had to look critically at their operations and what is happening is what has occurred in the oil industry for a number of years, where they are leaner utilities clustered around by service companies. The situation where one company would read both the gas and electricity meter could not have happened in the old days. Now as the utility players are being broken down into smaller units, horizontal integration is a distinct possibility. Alliances will take place in which companies may well read gas and electricity at the same time, and maybe even water. The examples are Hyder (Welsh Water and South Wales Electricity), United Utilities (North West Water and Norweb) and ScottishPower but I'm sure there will be other examples coming down the line."

(Source: Interviewee: Alan Curran, Ofgas)

Competitive meter provision and installation is some way behind meter reading, but some progress is being made. Key events have been the publication of Ofgas' *Codes of Practice for Meter Installation* and the start of a registration scheme for the approval of meter installers. There has also been a trial set up for competitive meter installation by TransCo and the establishment of a Network Code modification working group chaired by TransCo. The trial offers shippers the opportunity to have replacement meters installed by companies other than TransCo. In its transportation charging statement, TransCo has published initial rebate prices for meters installed by others in the trial. All meter installers who wished to participate in the trial need to be approved by Ofgas.

There is a clear recognition in regulatory circles that liberalisation of meter operations and data collection has been an inhibitor to sophisticated metering and the benefits that this would bring. Meter operation involving the functions of ownership, installation and maintenance have not yet been fully defined. It is in the area of meter ownership in which there is greatest debate. At present TransCo has a monopoly over meter ownership, and if competition is introduced there is likely to be the issue of stranded metering assets. This problem has been overcome in the rail industry where Railtrack owns the rail infrastructure and the trains are operated by franchisees who lease the rolling stock from financial leasing companies (Roscos). In the same way metering assets could be leased to companies who install and maintain meters while they are leased from financial organisations. It is yet to be seen whether Ofgas will force TransCo to sell some of its metering assets in order to introduce this regulatory mechanism.

8.4 SUMMARY

The regulatory structure in the gas industry is in a transitional stage from a vertically integrated structure to one in which gas transportation, shipping and supply is being unbundled. Competition is being introduced in the shipping and supply functions. The regulatory system that operated in the second half of the twentieth century has been gradually dismantled to make way for a more competitive and transparent system. This does not mean that the preceding system was wrong, merely that the management of gas operations has evolved. In this evolution, information technology has played a facilitating role in developing the competitive system.

Due to its ability to be relatively easily stored, metering of gas is not as crucial as in electricity or telecommunications (see section 4.3). Nonetheless field trials have been carried out in electronic metering systems, automatic meter reading and ultrasonic metering. Development of metering has been inhibited in recent years by the attempt to open the meter operation and data collection functions to competition. Two issues predominate. If competition is to become a reality in meter operations, a solution has to be found for stranded assets. This may be found by a leasing mechanism, which has been pioneered in the railway industry. With respect to data collection, electronic metering technology remains too costly to compete with manual pedestrian meter readers. If wide-spread electronic data interchange is to become a reality in the gas industry, the major impetus has to come from outside the gas industry, perhaps, multi-utility, multimedia or home automation functions.

CHAPTER 9

CASE STUDY No.4:

GAS IN FRANCE

9.1 INTRODUCTION

The use of gas via pipeline in France dates back nearly two centuries, François Lebon being the first Frenchman to use gas for lighting purposes. Its expansion was most spectacular when natural gas supplanted manufactured gas. The 'conversion' as it was called in the gas industry in France, lasted about twenty years (from the mid nineteen-fifties to the mid nineteen-seventies) and was marked by the successive arrival of sources of natural gas from different countries. As with electricity, gas companies were of mixed ownership prior to 1946. In 1946 both electricity and gas were nationalised together, as one joint company. The post-war Government was a coalition of Gaullists, Socialists and Communists with the principles of: "An economic system where profit and interests of individuals should not benefit at the expense of the nation as a whole. Rather these communal riches should be used for benefit of everyone." (Beltran & Williot, 1992: p.15). Certainly it is difficult to find an article of this time which is hostile to nationalisation.

It became apparent soon after nationalisation, that the administration of the joint Electricité-Gaz de France (EGF) was being dominated by the electricity lobby. There were a number of reasons for this. The scale of the electricity industry was larger than that of gas, making it the dominant partner. Also, electricity was seen as a universal necessity and had become, during the previous decades, the dominant mode of power for lighting and urban transportation. Most importantly, electricity was viewed as a strategically important resource, which was to be developed by indigenous resources such as hydro-electricity. In contrast, French resources for coal and natural gas were relatively scarce. This caused friction of the management of the two functions of EGF, and by 1947 the two companies were partially demerged into two separate financially autonomous organisations, Electricité de France (EdF) and Gaz de France (GdF). Exploration, equipment provision and research studies became independent while human resources, distribution and general affairs remained mixed (EdF-GdF services) (see Picard *et al.* 1985 and Beltran & Williot, 1992). This case study will consider the infrastructure and market for natural gas in France since the demerger of EGF, and then go on to investigate the role that metering technology has played in its development over the past twenty years.

9.2 INFRASTRUCTURE

9.2.1 Production

Today, Gaz de France (GdF) has a monopoly right to import gas under the 1946 nationalisation law. Under the law the management of the nationalised gas undertakings is the responsibility of a national public institution of an industrial and commercial nature entitled: "Gaz de France - Service Nationale" (Cameron, 1995). GdF is a public national corporation with a commercial character (établissement public national de caractére industriel et commercial). The company's capital is entirely owned by the French Government. Its legal basis lies in the Act of April 1946. Under that Act, eighty four per cent of the nationalised gas facilities were transferred to GdF and it is the sole importer and exporter of fuel gas into and out of France.

Despite its monopoly, the company is not a law unto itself. Under Decree No. 85-1108 of 15th October 1985 concerning gas transport by pipeline, it is necessary to obtain ministerial approval for all import contracts. It states: "Agreements, including contracts to import gas for the purpose of supplying it to networks operated under concession or authorization shall be submitted for approval to the minister responsible for gas" (Cameron, 1995).

France is poor in indigenous fossil energies and it now imports almost all of its oil, more than ninety per cent of its gas, and two thirds of its coal (Guichard & Casterman, 1994). In all, the national production only covers a little less than half of its energy needs. This results in an energy policy that rests on three pillars: there is a systematic effort for energy conservation; there is reliance nuclear energy for the production of electricity; and there is the diversification of imports, both in the nature of the energy and in their sources. This has resulted in Gaz de France being one of the largest importers of natural gas in the world. Domestic production of gas covers less than about ten per cent of the needs of the French market, and is declining. To guarantee the security of its supplies, over the last thirty years Gaz de France has built up one of the most diversified supply bases in the world. Its principal suppliers are: Russia, which provides 30% of supplies; Norway 28%; Algeria 20%; and the Netherlands 14%. Gaz de France also considers that the United Kingdom, Nigeria, the Middle East (Qatar, Abu Dhabi, Oman, Yemen, Iran) and Central America (Trinidad and Tobago, Venezuela) will play a significant role in the medium term in diversifying and balancing its supplies.

Gaz de France concludes long-term supply contracts, lasting ten to thirty years with producers. Short-term security of supply is ensured in two ways: underground storage facilities and so-called interruptible customers (who have access to substitute energy and whose natural gas supply can, with advance notice, be interrupted). Underground storage sites are used primarily to store surplus resources during low consumption periods and to make them available during high consumption periods. Interruptible customers are an additional means of adjustment used, in particular, to cushion the effects of certain unforeseen events (Cameron, 1995).

Two French companies, Elf Aquitaine and Total, are very active in the exploration and production of gas (Puyraimond & Bakkaus, 1994). Indeed, for more than thirty years, the French oil policy was implemented through these two semi-public groups. In recent years however, Elf Aquitaine and Total have been privatised. It should also be noted that the current GdF monopoly is by no means absolute. In addition to the special role of the distribution companies, Elf already imports directly from Norway and uses the gas in the Compagnie Française du Méthane (an independent gas transmitter) network in Central France, albeit in close partnership with GdF.

In France, gas production is concentrated in the South-West region with the deposits at Meillon, Rousse, Lacq and Saint-Marcet. It is Elf Aquitaine who operate these natural gas deposits. These meagre domestic stocks are supplemented by mine gas recovery plants in the abandoned coalfields in Northern France, operated by GdF. In 1994 GdF founded a company called GIE Methamine, from the co-operative venture (50:50 equal stakes) between Gaz de France and Charbonnages de France (CdF) to recover these mine gas deposits. Dwindling domestic stocks of natural gas and rising demand have been progressively supplemented from other countries. Imports of gas from Algeria began in 1965 and gas from the giant Groningen gas field in the Netherlands has been imported since 1967. Moreover, Norway's contribution to France's natural gas supplies has been increasing since supplies first came on stream in 1977. The construction of the NorFra pipeline, now links the Sleipner and Troll offshore gas fields in the North Sea with the French coast near Dunkirk. But it is Russia who is today France's primary source of natural gas. With Gazprom, the world's largest producer and exporter of natural gas, Gaz de France has developed extensive industrial and technological co-operation both upstream (research, liquefied natural gas, storage) and downstream (energy conservation, training). The USSR began supplying France with gas in 1976 (Beltran & Williot, 1992 and Lucas, 1979).

A key feature of the natural gas industry in France is the role of liquefied natural gas technology. Having imported Algerian LNG since 1965, GdF has studied, designed, built and operated LNG facilities and is now one of the world leaders in liquefying, transporting, storing and regasifying LNG (Barnett, 1995). Gaz de France operates two LNG terminals in France, at Fos-sur-Mer on the Mediterranean coast and at Montoir-de-Bretagne on the Atlantic coast. Also through its subsidiaries Sofregaz (consultancy) Gaz Transport Technigaz (transport), Messigaz and Méthane Transport (ship leasing) GdF has developed large-scale strategic and industrial partnerships with its suppliers (Coste, 1994).

9.2.2 Transmission and Storage

The freedom to transport natural gas in France is restricted to public undertakings or national companies in which the State or other public entities have at least 30% shareholding (Cameron, 1995). In effect, carriage is a monopoly of GdF except in the South-West where gas is transported through the Toulouse region by Société Nationale des Gaz du Sud-Ouest (SNGSO) and outside the South-West area by the Compagnie Française du Méthane (CFM) network.

In France the transmission of natural gas was regional in the nineteen-fifties, then became national in the seventies, is now European and it is the aim of GdF to be intercontinental in the future (Philippe *et al.* 1994). As of 1941, the RAP (Régie Autonome des Pétroles) or 'State-run autonomous petroleum company' began operating the fields of Saint Marcet whose production was intended to supply Bordeaux and Toulouse. Development of natural gas in France increased when Elf Aquitaine (then called SNPA, Société Nationale des Pétroles d'Aquitaine) discovered the field of Lacq. Gaz du Sud-Ouest (SNGSO) was then given the responsibility for the transmission and marketing of the natural gas in the South-West. For this purpose, SNGSO constructed pipelines that supplied this region. Also, during 1958 and 1959, Gaz de France built trunk lines to other parts of the French transmission system. This enhanced transmission system made it possible to supply the regions of Paris and Lyon. At that time, Gaz de France and Elf Aquitaine founded the Compagnie Française du Méthane, a subsidiary in charge of the transmission and marketing of natural gas over to a larger proportion of the country.

The French gas transmission system underwent a second phase of development, beginning in 1965, with the first deliveries of LNG from Algeria. From then on, the pipeline system developed at a sustained rhythm according to the arrival of new resources at the French borders. Gaz de France now participates in the trans-European system with MEGEL (Germany), SEGEO (Belgium) and BOG (Austria) and has completed French-Swiss and French-Spanish links. Thus, from now on, the framework under which the French transmission system will develop is established by the development of natural gas not only in France but in Europe as a whole.

There are 14 underground storage facilities throughout France (eleven in aquifers and three in salt caverns), accounting for one third of annual French consumption (Blondin & Ferrier, 1994). These natural gas reservoirs are buffers, which adjust supply to demand. Since daily consumption changes at a ratio of 1 to 8 between summer and winter and because over ninety per cent of French needs are met by imports, underground storage facilities have a tactical and strategic purpose. They guarantee supplies to customers if a major source of supply fails. Therefore the stocks account for 4 months of national consumption.

9.2.3 Distribution and Supply

GdF has been granted the franchise for all municipalities in France, apart from a few who retain direct responsibility for gas distribution. The exceptions to the GdF monopoly are set out in Articles 8 and 23 of the 1946 Act. Article 23 of the Act states that the municipal undertakings which already existed at the time of the Act can be excluded from its scope (Cameron, 1995). There are 12 régies (utilities) established by municipalities, two mixed economic groups (Sociétés de Distribution à Économie Mixte) in which the majority share is held by the State or by public authorities, and three non-nationalised enterprises. The most important undertakings are those of Bordeaux, Dreux, Grenoble, Monaco and Strasbourg (Aubert *et al.* 1994). Gaz de France is therefore responsible for about ninety-five per cent of natural gas distribution in France. There are also consultative bodies designed to co-ordinate links between GdF, EdF and local interests and to give advice to the chairman of the distribution region. The members comprise 12 representatives of the users (nine from the communes, two from industrial users and one from family associations) and one representative from personnel. The committees are not the same for gas as for electricity distribution. The non-GdF municipal concessions are granted for a period 30 years and are often delegated to private companies such as Suez-Lyonnaise des Eaux (SLE).

On several occasions GdF has been obliged to defend vigorously its monopoly on gas distribution. Notable cases have involved Commune de la Réole, Commune de Bonneville (Grenoble) and the municipality of Dreux all of whom wished to extend their concessionary rights in one way or another but were blocked by court rulings. However the professional organisation which represents the gas distribution régies (SPEGNN: Syndicat Professionel des Enterprises non Nationalisées) claimed that the ruling at Dreux departed from the competition rules of the European Union. This is a disturbing new departure for French gas policy in that European law may threaten the close relationship that GdF has with the French State (Cameron, 1995).

9.2.4 The Role of Gas in the Energy Market

As a result of a policy of price controls to combat inflation and competition from low-cost oil, by 1969 GdF was greatly in debt. Emphasis from this time on has been placed on financial recovery at the expense of investment. In this the enterprise has been largely successful, and since 1976 has been fully financially independent. This turn around in fortunes is even more remarkable considering that in the mid-seventies, the company suffered a massive operating deficit, due to equipment failure in the compression equipment for LNG from Skikda, in Algeria. The second contribution to the favourable evolution was in the conversion from town to natural gas. Another issue for gas is the relationship with electricity, and particularly the role of gas in the 'tout électrique, tout nucléaire' policy of EdF and the French State (Wieviorka & Trinh, 1989: p.50). This has resulted in a curious imbalance in energy policy where France is self sufficient in electricity yet it imports nearly all its gas. Despite this handicap GdF is now relying on its solid financial recovery to develop a new growth strategy, targeting expansion upstream and downstream both in France and internationally.

During the past four decades, the quantities of pipeline gas have increased considerably and now account for twelve per cent of the total primary energy used in France. Nevertheless this is still well below the average for the European Union (see table 7).

The low penetration is not only accounted for by greater strategic emphasis given to electricity but also by the lower population density and the need for a widespread distribution system. This geographical context makes the contribution of LPG in France more significant than in many of its European neighbours (Coste, 1994).

Table 7: Penetration of Natural Gas as a Percentage of Primary Energy Consumption by Country (1987 Figures)

Country	Primary Energy Consumption (Per Cent)
Federal Republic of Germany	17
Belgium/Luxembourg	16
France	12
Italy	22
The Netherlands	46
The United Kingdom	24
EU Average	19

Source: Beltran & Williot (1992: p.277)

For several years, Gaz de France has been working to open up new natural gas markets, notably co-generation and the natural gas vehicle markets. Co-generation represents more than twenty per cent of the increase in natural gas sales. The market has strong growth potential where combined heat and power is required. The clean air Act which the French Parliament passed in November 1996 has heightened Local Government interest in natural gas vehicles. As a response, Gaz de France has rethought its development strategy for natural gas vehicles to focus on public transport, street cleaning and urban utility vehicles. Partnerships with manufacturers and Local Government are being developed and a more extensive refuelling network is being organised. Nonetheless, due to the French Government's commitment to nuclear generation it can be expected that the use of gas for electricity generation in France will not increase rapidly.

9.2.5 Gas and the Social Structure of France

With over nine million customers in France, Gaz de France is committed to promoting a new approach to customer relations and paving the way for "a modern public service." Developed with several consumer organisations, the 'service performance guarantee' is at the heart of Gaz de France's commitments. This guarantee has eight commitments to service quality and are shown in Appendix V. GdF also works in close co-operation with Qualigaz; the trade organisations' quality-control agency (Casterman, 1994). On a public relations side, GdF has developed the *Gaz de France Foundation* and has stepped up its efforts in environmental protection, notably in co-operation with the French hiking federation. The restoration of the Pointe du Raz natural heritage site in Brittany is a major project and GdF also continues to develop its partnerships with Local Authorities for environmental conservation. This *Ecoville* scheme has the support of regional representatives of Gaz de France (its 'eco-network'), and in each case offers the most suitable scheme using all these facilities adapted to local context. Also in April 1996, a protocol agreement was signed by Gaz de France and the Ministry of the Environment for the restoration of 467 gas plant sites, which are still the Company's responsibility. The Company committed itself to carry out environmental audits of the sites.

In France, unlike other countries or industrial sectors in which joint research organisations exist, research and development is shared between gas companies and various institutes (Bureau, 1994). Every year, French companies grant very large budgets to these projects. These constant efforts in research and development have made it possible for the French gas industry to reach and maintain its prominent position in the world. The gas companies, Gaz de France, Elf Aquitaine, Total, and numerous companies in gas allied industries have set up research centres, including the French Petroleum Institute and CETIAT (the technical centre for ventilation and heating industries). These research programmes have often received funds from public authorities and more recently from the European Union.

Concern about employment is also paramount in French society, and unlike the UK, this is not seen as a flexible resource. Thus the *Employment Foundation*, was created in

1995 by Gaz de France, Electricité de France and three trade unions to help create permanent jobs in the community. The goal is to encourage employment, especially for young people, through four approaches: developing economic growth; training; adapting and reducing working hours; and ensuring workplace equality. It is also acknowledged that these initiatives require major changes in workplace organisation, and profit related pay schemes are also becoming more popular.

One of the cornerstones to the policy of French gas is GdF's role in the international gas market. Its strategy involves a number of areas. It acquires interests in foreign companies and creates companies with local investors. It makes national agreements in research, training and has scientific and technical co-operation agreements with other countries. The ambition is simple. Gaz de France aims to be an important player in the global gas market and to participate in the development of natural gas as a major source of world energy.

9.2.6 The Future Structure

The Ministry of Industry established a working group in 1993 to investigate the question of how to put more competition in the field of gas and electricity regulation (see also section 7.2.3). Chaired by M. Claude Mandil, Director General of the Energy and Raw Materials Ministry, the working group held 32 hearings during 1993 and studied developments in Germany, Spain and the UK. Regarding gas, it argues that GdF must retain a controlling role in the provision of gas and that this should be recognised by the priority award of import licences and preferential rights in storage and distribution. Also the company should have a "particular vocation to act in the international arena." A major concern is security of supply, and the report considers that this is GdF's most important responsibility. Existing supply contracts, supply diversity, storage capacity and interruptible contracts are deemed satisfactory in ensuring security of supply. GdF has three main responsibilities in these areas:

- monitoring and guaranteeing "an appropriate gas balance" to enable the authorities to issue import licences without putting the balance at risk;
- co-ordinating the operation of large underground storage facilities and the implementation of interruptible contracts;
- developing an international presence "to improve its efficiency in its traditional activities while ensuring an adequate return on investments."

The report supports the idea that large gas producers should be able to negotiate imports directly with international suppliers. The resulting competition "would ensure competitive supply." At the same time, the report advocates a unified negotiating position when faced with sellers in a monopoly. A single negotiating group is argued to be a solution (the *Single Buyer Procedure*). It recommends import licences for two categories: large networks and energy intensive industries. These would cover the life of the supply contract (fifteen years for networks as a minimum and seven for large industrial companies as a minimum). This should not interfere with the activities of GdF, especially in international markets. There would also be a contribution to flexibility of supply through adjustable contracts, as well as physical or financial participation in storage facilities or interruptibility commitments. The authorities would continue to approve individual supply contracts to ensure that the natural gas balance is guaranteed.

Gas exports could be treated differently since export is not a function of the importers, whose authorised quantities are set in accordance with the national gas balance. The export monopoly of GdF could be replaced by a series of licences issued by the authorities in accordance with the requirements of the national gas balance. Holders of import licences and producers would be eligible for export licences.

With respect to producing gas, the report recommends that gas producers should be able to sell their output to any other operator holding an import licence. Since production is in decline, this innovation would probably not have a dramatic effect. Unbundling should be introduced but only to the extent of separating integrated company's accounts, not its management.

Vignette I

A typical reaction to this in the UK is illustrated by this comment:

"Well, I think it is just a French form of central planning. I'm probably making this too simplistic, but in my contacts with Gaz de France it seems similar to what British Gas was twenty years ago, there is overmanning, complacency, and lack of efficiency. It strikes me that what seems to be happening in France is a resistance at a very high level in the central planning system and the Government machine that they are not going to open their doors to this (*Third Party Access*). They will justify this with arguments of national security and lack of indigenous resources. They will pay a price though, and I think the revolt over inflexible markets is just the beginning."

(Source: Interviewee: Alan Curran, Ofgas)

9.3 METERING

9.3.1 Metering Technology

Vignette II

At present the only measurement made on gas meters in France is cumulative volume. For different classes of customer there exists a choice of different calculations, each of which has its own specification. A feature of many apartment blocks in France is that they are communally heated, and gas consumption is collectively measured. In principle the meter is chosen as a function of the uses of gas and the specific types of appliances the customer has. In the main, the technique used for measurement in the domestic market is the diaphragm meter where the inner lining of a membrane is deformed as the gas flows past. With

larger consumers rotating pistons and turbines are used (see table 8).

Data is input in cubic meters on miniature hand sets. The data is then further down-loaded by attaching the portable to a mother station at the end of the meter reading schedule. The readings are then dumped on to a server at head office.

Table 8: Order and Size of Meters Used by Gaz de France

Meter	Pressure (bars)	Flow (cubic meters per hour)
Membranes	0 - 0.1	0 – 100
Rotating Pistons	0 – 70	1 - 1,000
Turbines	0 – 80	10 –100,000

Source: Gaz de France

For the individual domestic meters, the task of installation, the reading and the maintenance is under the direction of the combined EdF and GdF operation (EdF-GdF services). Installation of metering is the responsibility of the customers (under the oversight of EdF-GdF services) and the reading is carried out by EdF-GdF services. The distributor (GdF) on behalf of the client carries out the upkeep of the meter.

(Source: Interviewee: Jean-Claude Bardin, GdF)

9.3.2 Pricing

Part of the reason for GdF's financial problems (described in section 9.2.4) were due to the fact that tariffs were not structured to more accurately reflect the costs of supplying different customer classes. Prices charged by GdF to consumers also had to be submitted for ministerial approval, and in the fifties this meant that tariffs charged for expensive town gas were kept below cost due to social reasons. Consequently the tariffs charged did not reflect the costs of manufacturing, distributing and supply of gas. Also at this time the pricing of gas and electricity began to diverge with electricity going the marginal route in order to express the constraints of electricity generation (see section 4.3.1). But by the late fifties harmonisation in gas tariffs had also been achieved with three basic tariffs (Beltran & Williot, 1992: p.44). There was a general tariff for small consumers. This consisted of a fixed charge and a price per therm (it did not have a seasonal component). A similar tariff of the same structure was also available for larger customers. There was a tariff consisting of a fixed charge and a seasonal consumption charge for commercial and small industrial customers. For the very large industrial customers, a maximum daily demand and seasonal demand were also included in the calculations.

In 1985 industrial prices were decontrolled, creating a regulated and non-regulated sector. However, the Ministries of Finance and Industry still 'supervise' industrial prices to prevent cross-subsidisation from other sectors. Under a Decree of November 1990, a distinction is now made between tariffs de réseau public de transport (industrial consumers) and tariffs de réseau de distribution (distribution companies). Any changes made to the tariff charged to industrial consumers (up to 170,000 therms a year) also have to be approved by both of the above ministries. In this sector the key elements in setting prices are the average cost of supply and the estimated financial results of GdF, projected up to two years ahead. A principle of non-discrimination applies so that, in each region, consumers with the same supply and load characteristics will face the same prices. Interruptible contract account for more than half of GdF's total industrial sales and are related to the delivered price of heavy fuel oil of each individual consumer in the current month (Cameron, 1995).

Prices for domestic customers are subject to regulation by the Ministry of the Economy, according to Decree No 90-1029 of 20th November 1990. According to Article 2 of the decree, the price has to take into account the costs of maintenance and renewal of installations for storage, transport and distribution as well as the costs of providing the gas and of using the above installations. The sale of natural gas is also subject to VAT of 18.6%. In addition, there is a special tax on industrial, non-heating uses of gas above 170,000 therms a year. Introduced in 1986, the tax is known as the TICGN (Taxe Intérieure à la Consommation du Gaz Naturel). Within the range of domestic consumption up to the equivalent of 2,000 therms per year, GdF has four tariffs:

- Base: Cooking (up to 34 therms/year)
- B_0: Cooking and hot water (34-239 therms/year)
- B_1: 239-1, 024 therms per year
- B_{2I}: above 1, 024 therms per year.

All four tariffs have an annual standing charge and a commodity charge. The Base and B_0 tariffs are uniform throughout France but the commodity charge in the B_1 and B_{2I} tariffs vary by six regions with the more remote regions such as Perpignan paying eleven to fifteen per cent more than Lille or the suburbs of Paris. These variations are intended to cover the higher transmission costs to these areas. Over eighty per cent of domestic and commercial users are located in the two lowest-priced regions, whose commodity charges differ by only about three per cent between each other (Ofgas, 1989). In France there are an increasing number of customers on monthly billing, mostly through automatic bank payments, based on estimated annual consumption.

9.3.3 Applied Research

Gas Metering is included in the research and development efforts of Gaz de France.

Vignette III

The meter for residential users, which has been limited to measuring the quantities of gas delivered is now given new functions. To develop interactive communication systems between Gaz de France and its customers, almost eighty thousand intelligent *Dialogaz* meters were installed for customers at the end of 1996. The installation of 2,500 experimental Communicating Customer Interfaces (ICCs) has also started in two distribution areas. *Dialogaz*, so named because it evokes its purpose of communication and is fully electronic. Some of the new *Dialogaz* functions are directly connected to measuring, such as the display of consumption and its monetary value. Other functions bring in new services to the consumer, such as safety, monitoring of the appliances and optimal energy management. Features include a shut-off valve operated by the flow rate that can be switched from a distance, a multi-functional display, remote meter reading, and an output for telephone connection.

There is also an international co-operative effort by Gaz de France, Ruhrgas, British Gas and Gasunie, together with other manufacturers, to launch a research programme for ultrasonic flowmeters (see also section 8.3.3). Ultrasonic flowmeters replace the diaphragm meter by measuring the flow of gas by ultrasonic techniques. Also in the industrial market Gaz de France in collaboration with CD Gaz, has perfected a very compact new device that incorporates the functions of pressure reduction, regulation, metering, filtering and safety. The first example of this equipment called *PDIM* was installed at Eurodisney in 1991. During 1993, the 'variable throat nozzle' version of this equipment obtained the authorisation to be used for a larger number. A second

version the 'turbine' version - came out in 1993; since then, about fifteen appliances have been installed and brought into service. The 'turbine' *PDIM* provides the same advantages as its predecessor, with a traditional gas turbine meter. The key achievement in distribution is the integrated multi-functional pressure regulating station. The design of this equipment combines in one appliance the functions of pressure reduction and flowmetering and the position of the pressure regulator is used to determine the flow of gas after a computer has taken into account the pressure and temperature value. One thus obtains a piece of equipment cast in one piece, which is not very cumbersome, may be buried, and therefore is well-adapted to the dense urban context. In addition, the computer is easily integrated into a remote management system. Metering development is also continuing in production where the operations involve techniques that are related and sometimes combined. The principal research projects are related to controlling multi-phase flows (gas-condensates-water), so that mixed effluent can be sent to treatment units without previous separation. These projects deal with: perfecting multi-phase flow models and programs; multi-phase flow metering; and prevention and inhibition of hydrates by perfecting new dispersing additives.

(Source: Interviewee: Dominique Plumejeaud, ATG)

9.3.4 Standards and Protocols

The network metrology and equipment department of GdF models the comparative performance of different metering techniques. The research and development division also has facilities situated near Paris which is approved by the French Accreditation Committee (COFRAC). Its work focuses on the safety and reliability of installations: upstream of the meter (improvement of maintenance and network management) and downstream (in particular the *Dialogaz* and Communicating Customer Interface, ICC, projects). More generally the specifications for the harmonising of metering techniques and increasing generic user requirements for gas metering have been set out by the

CEN TC294 in document reference WG1/N65E. CEN TC294 is the technical committee concerned with standardisation of gas metering in Europe.

The players in the French gas industry are multiplying their efforts in order to develop and offer new services that rely on the innovative new technologies in home automation and remote control facilities. The penetration of electronics in the residential sector (home automation) is important for the natural gas consumer, whether in the field of heating control and management, energy meters or safety. Of course, this development in the gas trade can only be founded on an exemplary level of quality in supplying natural gas, based on informing the customer, quality, metering, billing, and advice about tariffs etc. An example of this is tenant-controlled central heating. This combines the central production of heat and the individual control of comfort and service charges. There are two versions, one which bills by sales of gas distributed (by using individual meters), and one which bills by sales of heat (by using heat meters).

Vignette IV

As far as GdF is concerned, it does not wish to trouble its customers with the hassles of meter reading. Faced with this demand, GdF is now putting in place systems to read from a distance. With the integrated services of EdF-GdF, potential savings can be made and a common architecture for gas and electricity metering is being considered but there is a conflict of interest:

"EdF wish to develop a power line carrier technology to take advantage of the integrated electricity network. GdF however do not wish to be tied into this technology which may be expensive to develop and increase its dependency on its electricity partner. A low power radio network may be the compromise solution."

(Source: Interviewee: Phillippe Vanbleu, EdF-GdF Services)

The integration of these systems of metering is expected to provide new services for customers. This will involve better techniques in a number of areas. There will be system efficiency through, temperature correction, prepayment, load

management, system security and maintenance. It will improve customer service through standardisation of tariffs, simplicity of billing and advice about rates. This will add to the development of France's integrated digital telecommunications network through systems such as teleswitching and automatic meter reading as well as new technologies in home automation and remote control facilities.

"The penetration of electronics in the residential sector (home automation) is extremely interesting for GdF, whether it be in the field of heating control and management, energy meters or safety."
(Source: Interviewee: Phillippe Vanbleu, EdF-GdF Services)

9.4 SUMMARY

As the market liberalisation policy of the European Commission is implemented across the Continent, the French Government and parliament is under pressure to pass reforms designed to curb GdF's potentially anti-competitive practices in its import, transmission, distribution and supply businesses. This clearly conflicts with the *Single Buyer Procedure* of the Mandil Report. The subsidiarity clauses in European legislation should be enough to maintain GdF's near monopoly status in the medium term. Despite this, Gaz de France may already be making moves behind the scenes to steer the transfer of ownership into the private sector. There are reports, officially denied, that GdF has discussed with the French oil company Elf Aquitaine to purchase some of its capital. If other French companies are similarly attracted by such offers, then GdF may be fully privatised. On the other hand, a stock exchange flotation as was done with British Gas in the UK seems unlikely.

The resources of gas available to France are scarce and, with the exception of the deposits in the South-West of the country, supplies have had to be imported at higher cost or subject to the normal commercial market forces. As a result GdF has had three main preoccupations: its precarious finances; to secure supplies from outside France; and to find markets. The French energy market remains dominated by nuclear power generation. As a result Gaz de France appears a relatively timid organisation in comparison to its larger sister organisation EdF. One of the exceptions to this is in metering where GdF have a considerable influence on investment on new communication technology. The multi-utility relationship of EdF-GdF services is interesting in that it is a legacy of an integrated strategic national energy policy rather than market forces, as it is in the UK.

CHAPTER 10

CASE STUDY No.5:

WATER IN THE UK

10.1 INTRODUCTION

Any location in The United Kingdom is less than 120 kilometres from the sea, which means that compared to many countries, there are no long rivers. Also the geology does not permit large amounts of underground storage of water nor does it provide natural aquifers. This reliance on surface water, which accounts for seventy per cent of public resources, represents one of the most significant constraints to water supply in the UK. The demand for surface running water has put particular pressure on the environment. These geographical factors proved of great importance to the development of the public water supply during the time of industrialisation at the end of the nineteenth century. This may have been the reason for the gradual progression from local to central administration of water resources in the UK over the past century (Barraqué, 1995).

The regulation of water in the United Kingdom has regional variations. In Northern Ireland, management has traditionally rested in the centralised control of the Ministry of Northern Ireland, situated in London. In Scotland, on the other hand, three publicly owned water authorities manage water. This case study however, will consider principally the regulatory system operating in England and Wales, since this has gone through most radical change in the past twenty years and contains ninety per cent of the UK population. A briefer discussion will be conducted on the regulation in Northern Ireland and Scotland.

10.2 INFRASTRUCTURE

10.2.1 A Brief History

The 1945 Water Act brought together previous water legislation in a waterworks code and encouraged amalgamation of water companies. A Government survey 30 years earlier had identified 2,160 water undertakings, including 786 Local Authorities. By 1963 there were 100 Water Boards, 50 Local Authorities and 29 privately owned statutory companies. The 1973 Water Act consolidated these Boards into 10 multi-purpose Regional Water Authorities whose role was to plan and control all uses of water in each river catchment area. They had regulatory responsibilities for water conservation, controlling pollution of inland and tidal water, land drainage, flood control and fisheries, as well as for water supply and sewerage. One of the major by-products of this regionalisation process was to enhance the role of Central Government at the expense of the Local Government in the management of water (Barnett, 1996: ch.6).

Then, the management, disencumbered of Local Government control, had the freedom to build large reservoirs in the headwaters of the valleys, on a forecast of demand that was very optimistic. Meanwhile there was little investment in the purification and treatment plants, which made the water system in UK one of the oldest in the world. As a result The Water Act (1983) changed the organisational structure in preparation for modernisation, refurbishment and final privatisation in 1989 (Barnett, 1996; Barraqué, 1995 and Kinnersley, 1994).

Vignette I

"There were several reasons for privatising the industry. The most significant was that the water industry had seen considerable under-investment in the public sector over the previous decades due to financial constraints. By privatising the

industry, the Government hoped also to privatise the required investment programme. Another perceived advantage of privatisation was that the water companies would have the benefit of longer regulatory cycles and would not be used as political pawns. Since 1989 it has become obvious that privatisation has not addressed the major issues affecting the water industry. The following three points explain why. First, national assets (the water industry) were passed with little change to the private sector at the time of privatisation. Second, it is essentially public expenditure on the water industry that has been privatised. Third, pricing under Government ownership was effectively a water tax and all costs were passed straight through to the consumer. In the private sector, water charges remain directly related to costs in a similar way. It can also be seen that a history of the administration of water resources in the United Kingdom has been a slow progression and a weakening of local control. Local Authorities have a relatively small role to play in the management of water resources unlike in other parts of Europe."

(Source: Interviewee: Bob Sheldon, UKAMRA)

10.2.2 Economic Regulation

The basic structure of the water industry in England and Wales today was laid out in the Water Act of 1989 (subsequently superseded by the Water Industry Act of 1991) which addresses economic regulation of the industry, and the Water Resources Act 1991, which deals with the Environment. Under this legislation the 10 Water Service Companies (WSCs) created by the 1973 Water Act were appointed as water supply and sewerage undertakings. Each company is a wholly owned subsidiary of a water holding company, which is a public limited company (Hall, 1998; Barnett, 1996 and Kinnersley, 1994).

In 1973 there were also 29 independent water-only companies (the statutory water companies) which had no sewerage functions at all, but in total provided water to around twenty-five per cent of the population of England and Wales. Since 1989, 12 water companies have been involved in mergers and one has been taken over by a water and sewerage company. So there are now only 21 water-only companies. Water companies have also been active in creating multi-utilities.[11] This has obvious advantages for reducing common administration and metering costs (Hall, 1998).

Since privatisation in 1989 there has been a substantial amount of investment in the national network of mains and water treatment and sewerage services. This has been necessary because of comparative neglect over many years by successive Governments, and to meet the EU directive covering urban wastewater treatment (UWWTD). In order to fund this investment, much of the cost has had to be passed on to customers (Barnett, 1996).

Ofwat (the Office of Water Services) is a non-ministerial Government department for which the Director General (the regulator) has responsibility for the economic regulation, and to a lesser extent the social provisions of the industry. The Director General is appointed for a fixed term by the Secretary of State for the Environment. Ofwat is not subject to direction about its judgements relating to the industry, but must report annually to the Secretary of State. The private companies pay its budget, each paying a proportion equivalent to its turnover. This accounts for £9 million per year.

Ofwat has primary duties both to the regulated companies and to their customers. For the companies it should ensure that:

The functions of a water and sewage company are properly carried out in all areas of England and Wales; and ensure that the companies can finance their functions. For customers, the regulator should ensure that no undue preference is shown and there is no undue discrimination in the way companies fix and recover charges. Other aspects of customers' interests are protected, including quality of service and benefits from the sale of land transferred to the companies at privatisation or acquired since then. If a company acts against the public interest by misusing its monopoly position and fails to

[11] e.g. Hyder (Welsh Water / South Wales Electricity) and United Utilities (North West Water / Norweb).

accept the suggestions of the regulator, the regulator may refer that company to the Monopolies and Mergers Commission (MMC). To take account of customers' interests there is also the independent Water Consumers' Council (WCC).

Since there is little or no direct competition in the water industry, the regulator has introduced 'yardstick' or comparative competition. This compares the performances of the regional water companies against each other. The economic regulation of companies relies on the RPI-X format (although the X factor is known as a 'K'). The K covers the whole company (water supply and treatment as well as sewerage) in a system known as basket tariffing. Each water company has its own K that is made up of two parts, an efficiency factor 'X' and a quality factor, 'Q'. The reason for this two-part formula is first to stimulate inefficient water companies to improve their performance and second it is a recognition of the large capital expenditure programmes that the water companies are having to undergo over the first ten years after privatisation. Without recognition of this K factor, no companies would be able to invest sufficient amounts. The regulator has the option to review the K factors after five years (Hall, 1998; Barnett, 1996 and Kinnersley, 1994).

In order to implement this 'yardstick' competition in the industry and to take account of the different factors that affect each water supplier, the Department of the Environment (DoE) conducted an efficiency review in 1989. This compared costs for each supplier with the factors that affected those costs. From the findings of the review, the water suppliers were each allocated cost reduction targets. This process is not flawless. There is great difficulty in the water industry in defining unit costs accurately, and accounting for regional demographical and geographical variation. The distinct regional pattern of K factors is largely due to the UWWTD. Under this directive, certain levels of sewage collection and treatment must be provided. So for example, water companies with long stretches of coastline in relation to population, such as Southern Water, had to spend particularly large amounts installing new and additional treatment facilities, so the K factor is higher. As a consequence, the X factor is serving to reduce real prices, whilst the Q factor allows for necessary increases. Without the desegregation of the K factor into its components, its composition would have been largely hidden from the public, probably resulting in general criticism (Barnett, 1996).

Vignette II

Despite this there are still concerns that the RPI+K formula is not succeeding in the water industry:

"The increasing prices have been due to a system of cost pass-through. Investment in new capital projects can be passed through to the customers with an economic rate of return. This has led to accusations that the WSCs have placed more emphasis on capital projects such as new reservoirs, purification and treatment plants boosting their capital value (and as a consequence their return on that capital) rather than use revenue expenditure in fixing leaks and installing meters."

(Source: Interviewee: Bob Sheldon, UKAMRA)

In saying this, initial estimates of required capital expenditure made at privatisation have generally not been met. The water companies have made abnormally large returns relative to other companies in the FT-SE since privatisation. For example, North West Water (now merged with Norweb to form United Utilities) has handed £180m back to customers and shareholders since privatisation. This suggests that: either the investment plans were too ambitious or; too little emphasis has been placed on demand side management or; water companies were able to take advantage of generous K factors and enjoyed larger returns on capital employed. In practice, all these factors had a part to play.

"As a vertically integrated public utility service, the water industry is faced with few risks compared with many other industries. As a consequence, the average stock price of water companies is generally not expected to outperform FT-SE significantly. Efficiency improvements made since privatisation should produce steady profits for a water company, but if the regulator has access to sufficient information to regulate that company tightly, then persistent out-performance of FT-SE would not be expected. It can therefore be concluded that the regulator's

lack of perfect foresight has contributed to the strong performance in water stocks."

(Source: Interviewee: John Heathcock, Schlumberger)

There have also been suggestions that direct punitive action may be required where water companies fail to provide basic services. In the summer of 1995, the UK water industry was the subject of considerable controversy resulting from the widespread and prolonged water usage restrictions following months of low rainfall. Whilst hose pipe bans were common, some areas, notably parts of Yorkshire, were required to use stand-pipes as water supplies were brought in from other regions by tanker. The controversy centred on the high level of leakages in the infrastructure of water companies, whilst some companies continued to make significant profits.

A further criticism of the periodic review process is that water companies can 'window dress' their accounts and investment strategy in the year before a periodic review, to make their investment requirements appear larger than they actually are, thus getting than a larger K factor in the review.

10.2.3 Environmental Regulation

One of the shortcomings of price capping as a means of regulation is that there is no direct incentive for improving quality of the product or service. This has generally been left to two external agencies The Environment Agency (EA) and The Drinking Water Inspectorate (DWI) (Hall, 1998 and Barnett, 1996).

The Environment Agency's duties and powers relate to: flood defences; water resources; pollution control; fisheries; conservation and recreation; and navigation. The Environment Agency has responsibilities for all rivers, reservoirs, estuaries, coastal water up to three miles from the shoreline (and for migratory fish up to six miles from the shoreline) and water stored naturally underground. By the terms of the Water Resources Act, these are all 'controlled waters' and it is an offence to cause any polluting matter to enter these waters (Barnett, 1996).

The Environment Agency has the power to decide whether water quality in any place meets the required standards and if not, to determine the most effective way to bring about an improvement. It also has the power to set and enforce necessary quality standards of discharges to all types of watercourse. It will also take action against unauthorised pollution discharges and constantly monitors water quality all over England and Wales. The Agency is also concerned with the general management of water resources, including resource planning and the licensing and regulation of abstractions from both ground-water and surface water. It is also involved in a programme to alleviate low flows on a number of rivers, and regulates fisheries by a system of licences that helps build up and conserve stocks both on rivers and in coastal areas. Within its watercourses remit it maintains over 1,000km of sea-defence works and many thousands of kilometres of river embankments (Barnett, 1996).

The water companies must supply wholesome water according to standards laid down in the Water Supply Regulations of 1989. The Drinking Water Inspectorate (DWI; part of the DoE) ensures that water companies comply with these statutory duties. Where standards have not been met, water companies are forced to enter into legally binding undertakings to bring about the necessary improvements, for example by installing additional treatment facilities (Barnett, 1996).

Vignette III

"It is important for the quality regulators to beware of being more demanding than current regulations require. Although it may ultimately be desirable for the water companies to exceed the requirements of the UWWTD and other quality directives, making such quality improvements can be extremely costly. The water supply and sewerage companies therefore have to balance exceeding regulatory

requirements with the costs of doing so. Similarly, the quality regulators must take into account the economic costs of their proposals when setting timetables for compliance with EU directives."

(Source: Interviewee: Ronnie Yellon, Anglian Water)

Pollution and water quality have become highly politicised, and sensitive issues. Thus it is important for the various regulators to co-operate and balance the relative importance of their objectives. The water companies have, in the main, borne the cost of meeting pollution requirements because of the difficulty of controlling sources of pollution. However, this puts the regulator in an extremely awkward position:

"Quality and pollution requirements are largely defined without reference to water companies' ability to pay. This difficulty is increased when it is the combined impact of a number of third parties that causes the pollution, even although individually they may be following agreed standards. For example, a number of farmers may be using a number of fertilisers and pesticides which independently caused little damage but when combined form a major pollution hazard."

(Source: Interviewee: Ronnie Yellon, Anglian Water)

The strategy of 'polluter pays' then becomes untenable since it is unfair to charge an individual who is following agreed guidelines. However, it is possible to enforce it in the situation where an industrial firm is discharging effluent into a river. Such firms might be forced to ensure that all effluent reaches a certain quality standard, or be given a certain level of pollutants that they are legally allowed to discharge.

10.2.4 Scotland

In Scotland the Ministry of Agriculture is responsible for fishing and ground drainage. The Scottish Secretary State for the Environment is responsible for the rules for the preservation of water resources, for the quality of rivers and estuaries. Up until 1994

The Scottish water supply and sewerage services were run by Local Government and organised by regional and island councils. In November 1994, Scotland's water and sewerage system was reorganised into three public water authorities, East, North and West. The new authorities are expected to provide efficient, cost-effective delivery of water and sewage services and to ensure that they meet water quality and environmental standards. A separate body called the Scottish Water and Sewerage Customers' Council was established to represent consumers' interests and monitor the authorities' performance. The other bodies of importance in the Scottish water industry are The River Purification Boards, which monitor the environment for pollution and compile water resources information (Barnett, 1996).

10.2.5 Northern Ireland

The water industry in Northern Ireland is split into a headquarters group and four operational divisions that are organised by geography. The headquarters group is responsible for legislation and planning and the four divisions perform day-to-day sewerage services. Water pollution is administered by the DoE's environment service, and drainage and flood protection by the Department of Agriculture. It is expected that the Northern Ireland water industry will be reorganised, depending on the success of the recently elected devolved parliament (Barnett, 1996).

10.2.6 Competition

The water industry is the most naturally monopolistic of the four utilities discussed in this thesis. The introduction of competition has been seen to be unlikely by both regulators and the Government, and therefore regulation of the operating functions of the industry is far more important than the development of new competitors. The main problem for the regulator in promoting competition in the water industry is the massive (and sunk) costs involved in setting up efficient infrastructures. Very few companies would be willing to take the associated risks. Although, it might be possible to encourage competition to some extent by developing a national carriage network. Water supply companies could then compete for business, through access to the network in a manner similar to electricity supply companies. However, this scenario would require extensive monitoring and metering of companies providing water to the national network, because water, unlike electricity, can be of varying qualities. Nonetheless, it is also possible for Water Service Companies (WSCs), whose boundaries touch, to compete for customers on the borders, and this is being encouraged (Ofwat, 1995). Nonetheless, it is very difficult to envisage a *Third Party Access* market developing as in the electricity, gas and telecommunications industries.

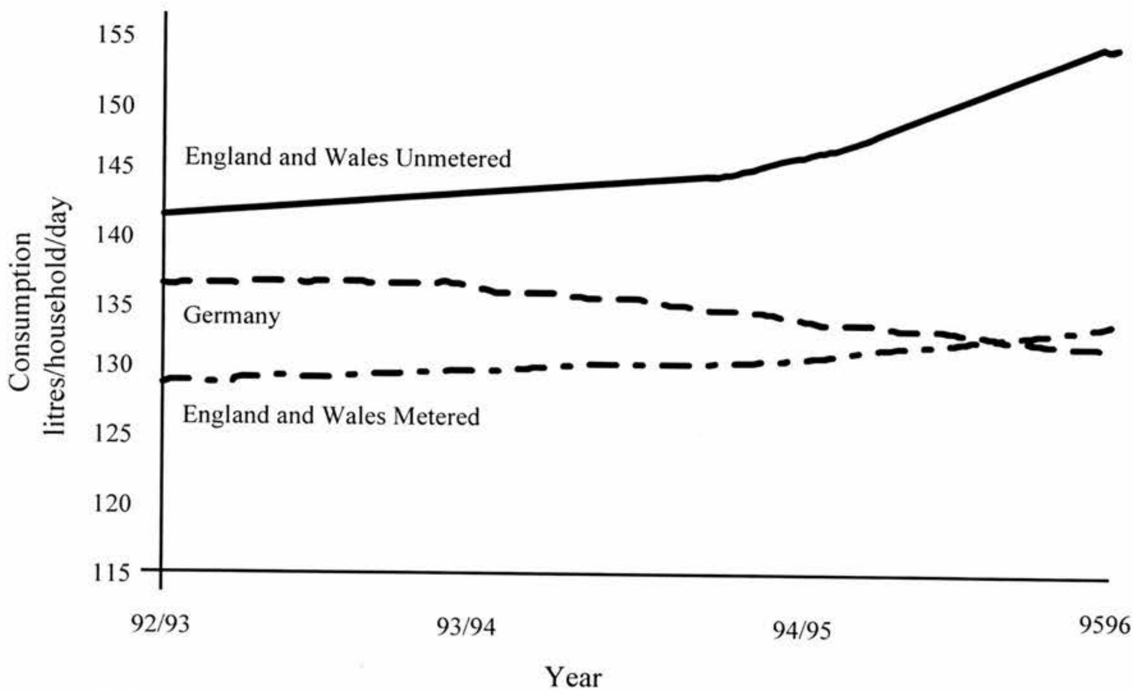
10.3 METERING

10.3.1 Methods of Metering

There are two classifications of meters in the water industry; operational and revenue meters. Operational meters are situated at reservoirs, treatment plants, booster stations and borehole stations. They measure the input and output of water to the distribution systems. Those are generally magnetic flow meters and measure an accuracy to plus or minus half a percent. The distribution system is split into demand areas and most companies have a networking demand profile, which is mapped on to computer systems. Different losses, throughput, pressures and demands can be input so that accurate forecasting can be calculated. For example Severn Trent Water have something like 800 demand areas covering 7,000 square miles, consisting of 8 million customers, and they have 3 million properties.

Revenue meters are used in or around the customers' premises. In England and Wales there are around 22 million billed properties consisting of 20.3 million domestic premises and 1.7 million non-domestic premises. Of the domestic premises 1.8 million (ten per cent) are metered and 18.5 million are unmetered (ninety per cent). Of non-domestic premises seventy-nine per cent are metered.

Figure 14: Trend in per Capita Consumption of Water in Germany and England & Wales



Source: Hall (1998)

Figure 14 shows that the trend for water consumption in England and Wales is on the increase, with metered consumption increasing by 3.9 per cent over the last five years and unmetered consumption increasing by a staggering 13 per cent over the same period. It is quite sobering to consider that per capita consumption in Germany has decreased by 8 per cent over the same period. Recent research by Mid-Kent Water confirmed that metering is effective in curbing consumption in households using hose pipes and sprinklers, although the research suggested that reduction in consumption was nowhere near as significant in homes with a lower rateable value (*Utility Week*, 1997).

Table 9 shows water consumption (by volume and by percentage) in the UK. Public water supply accounts for over fifty percent of daily consumption with uses by industry and power generation making up most of the rest in almost equal measure. Table 10 also provides some further statistics on other characteristics of the UK water network such as leakage and demographic profiles.

Table 9: Water Supply by Sector (1994/95)

Sector	Millions of Litres Per Day	Per Cent
Public Water Supply	16,735	52
Industry	7,090	22
Power Generation	7,969	25
Agriculture	402	1
Total	32,916	100

Source: Ofwat (1997a)

Table 10: Consumption Patterns in the UK (1994/95)

Per Capita Consumption (litres per household per day)	144
Leakage per Domestic Connection (litres per connection per day)	243
Length of Mains per Domestic Connection (meters per connection for 10m Supply Pipe)	29
Length of Mains per Domestic Connection (meters per connection for 5m Supply Pipe)	24
Approximate Population per Domestic Connection	2.5
Metered Households	10 Per Cent

Source: Ofwat (1997a)

Vignette IV

The introduction of metering in the water industry faces a number of hurdles. From the water company's point of view changing from a rateable charging form of pricing to one that is done by metrology introduces a number of risks. The way that price setting works is that the introduction of metering affects the volatility of a company's income:

"We (the WSCs) consequently face greater risks with metering. For example the regulator has to take this into account in the cost of capital when financial ratios which set 'K' are being considered. If metering is roaring ahead faster than we anticipated then our volatility (cash flow is going to vary) is going to be greater than first thought."

(Source: Interviewee: Ronnie Yellon, Anglian Water)

Therefore in the periodic reviews done by Ofwat the regulator and the water companies have to agree a target for the number of households paying by meter by a certain date:

"For example in 1994 Anglian Water agreed the installation of 365,000 new meters by 2000."

(Source: Interviewee: Keith Edwards, Anglian Water)

The other issue is the customers' perception of metering. The Labour party prior to the 1997 election was on the whole anti-metering. Its concerns were about the relationship between metering and public health:

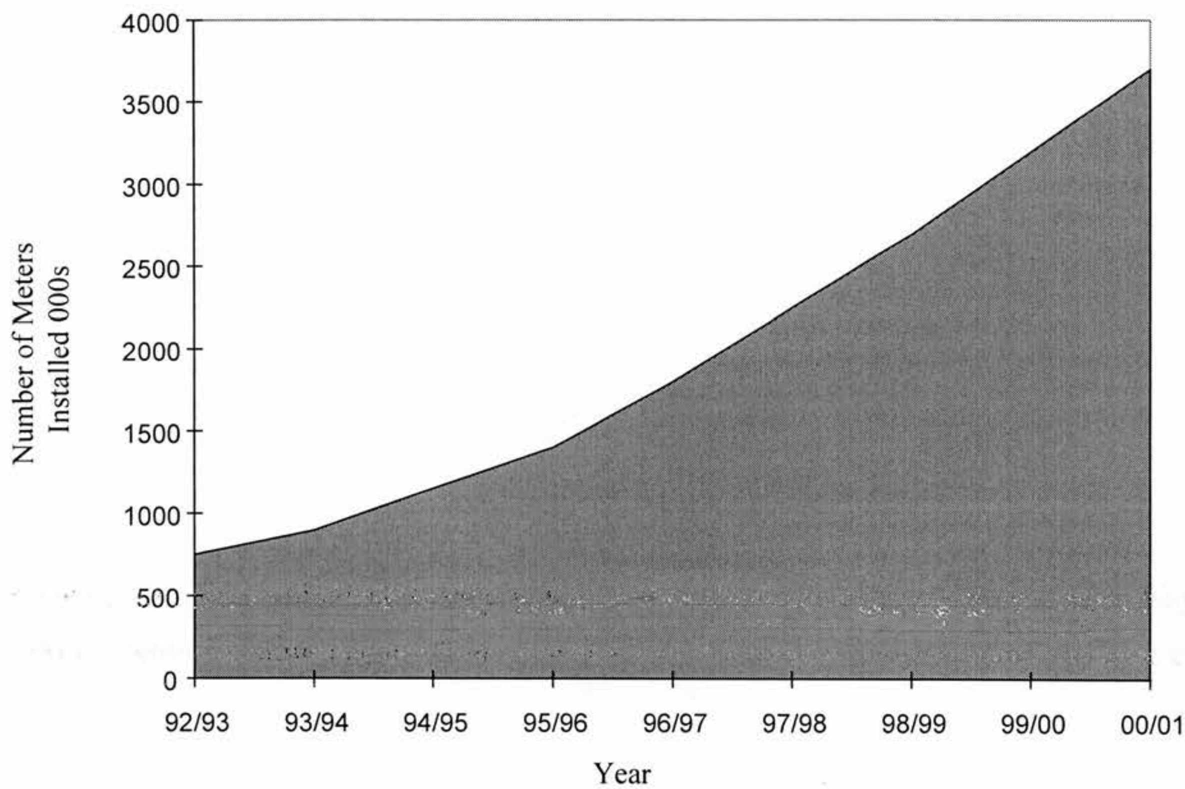
"There is a knee jerk tendency that people associate metering with public health issues because of the demand effect of metering."

(Source: Interviewee: Ronnie Yellon, Anglian Water)

Also there will always be winners and losers when any form of pricing mechanism is changed. In the case of water, the changing of a flat fee based on rateable value to one based on the amount of water consumed will have considerable demographic differences. A consumer who is in a low rateable value area and has high water consumption will fair worst, while customers in high rateable value areas with low consumption will fair best.

Figure 15 shows actual and projected water meter uptake in England and Wales up to 2001. The attitude and policy towards metering varies from company to company. Anglian Water has the maximum penetration of the household market with thirty-three per cent compared with Portsmouth which has a penetration of 0.1%. In the non-households market, Chester has the highest penetration with ninety-four per cent and Bristol the least with fifty-nine percent. The variation in policy depends on a number of factors both spatially a temporally.

Figure 15: Actual and Projected Water Meter Uptake in England and Wales



Source: Hall (1998)

Vignette V

Anglian Water is geographically the largest of the ten Regional Water Service Companies of England and Wales:

"The region stretches from the Humber to the Thames and to Oxfordshire in the West."

(Source: Interviewee: Keith Edwards, Anglian Water)

It has therefore a critical size in that it can gain economies of scale, which cannot be achieved by smaller companies like Portsmouth. Anglian is also situated in the driest part of the UK and has a large proportion of arable farming land in its territory. This makes the water supply liable to nitrate run-off resulting in high treatment costs. This all means that in Anglian Water's territory, water is a more valued resource than it would be in the North of England or Wales:

As a consequence "Anglian Water had 600,000 meters installed by 1998 and plan to have 1,600,000 by 2014."

(Source: Interviewee: Keith Edwards, Anglian Water)

On the other hand, companies such as United Utilities (North West Water) and Hyder (Welsh Water) have very little interest in installing meters.

There is also variation due to customer perceptions:

"We have seen over the last few years a change of perception of meters. Quite a few companies are installing them but I think that there are 'flavours of the month'. The emphasis is different depending on the shorter term agenda and I would suggest that it is political rather than regulatory. For example we (the WSCs) have now got agreed mandatory leakage targets, which are largely untenable and not based on anything realistic. Simply picking out one piece of the jigsaw and placing a target on it for political capital are the sorts of issues we have been talking about."

(Source: Interviewee: Ronnie Yellon, Anglian Water)

Yorkshire Water, with some 2 million customers, has probably had the most political flack to deal with over the last few years. It was this company's chief executive who during the 1995 drought, advised his customers that they could bath in one bowlful of water while taking his baths at his mother's house in a neighbouring water authority area. Yorkshire does not have the problems of Anglian with respect to agricultural contamination and also has a more healthy rainfall than many regions. Yet it does have with trouble over meeting demand, and it is politically and environmentally unfeasible to build more reservoirs. The only practical solution, Yorkshire Water argue, is to install meters to control demand. It therefore has around about 400,000 (about twenty per cent) meters in installed in domestic premises.

(Source: Interviewee: Alan Addy, Yorkshire Water)

Severn Trent Water (with domestic meter penetration around sixteen per cent), like Anglian Water have a policy to meter everyone. To some extent Severn Trent shares some of the same environmental issues as Anglian and as time goes on more attractive packages are being derived to encourage customers to install a meter. "Up to about two years ago people had to pay to get their meter in, now that is not the case."

(Source: Interviewee: Bob Sheldon, UKAMRA)

Every company has different policies about what types of meters are installed. In Anglian's case there are two types of meters that are fitted for domestic customers:

"Around ninety-five per cent are standard mechanical manual read meters placed outside the customer's property. The other five per cent are meters put in internally. For all of the internal meters they have a pulsed output with some kind of remote reading device. On the commercial and industrial side, most of the meters are mechanical, although some are 'solid state' meters, depending on the application. For example, some of the largest consumers have a telemetry connection. In Anglian Water the top hundred industrial customers have a link to

its telemetry system and Anglian provide them with a download of consumption information for their benefit. We (Anglian) are looking to extend that to some of our other customers on our industrial side because we see that as an important service."

(Source: Interviewee: Steve Marjot, Anglian Water)

Throughout the UK a meter only measures the volume of water which is used. No maximum demand or flowrates are measured. On the 'solid state' industrial meters 15 minute consumption is recorded, "so they (the customer) get their meter reading plus a consumption profile." At this moment there is no 'time-of-use' component for domestic customers. Traditionally water meters have been installed in pits in the ground. This was for ease of access and for legal reasons, namely that the stop-cock was in the street and if it was installed in the customer's house it would be attached to the customer's own water supply network. There is now a trend towards installing internal meters throughout the water industry. "This is a reflection of increased customer focus we (a WSC) now have as a company. Customers want it internally or they want it accessible, either in a garage or in the side of a house so there is a reason for doing this." This also means that it is closer to an electricity or telephone line if the reading needs to be downloaded automatically.

(Source: Interviewee: Steve Marjot, Anglian Water)

10.3.2 Pricing

In The Water Act 1989, it states that charges for water are prohibited with reference to rateable value after 31st March 2000. Immediately Labour gained power it held a 'Water Summit' (19th May 1997) where the Deputy Prime Minister, John Prescott announced Labour's new policy on water:

"The Government will review the system for charging of water including future use of rateable values and metering policy. The review will cover debt recovery arrangements (including disconnection) and the use of prepayment units." (Hall, 1998)

Despite this statement the UK Government still looks to water companies to develop tariff structures that encourage the efficient use of water such as, rising block, seasonal, summer surcharge, time of day, or maximum demand charges using marginal cost pricing facilitated by metering technology. These principles are supported by Ofwat who believe that customers' bills should broadly reflect the costs that the customer imposes on the system (Ofwat, 1997b). Thus tariffs should be set with reference to the continuing cost of augmenting supply. In order to do this the Director General believes that metering is the fairest method, but Ofwat does not go as far as advocating universal metering.

The pricing of water and sewerage services depends on a number of factors including: whether it is drinking water; water for industry or; for agriculture etc. Independent of what water is being used for, the pricing process is the same either by rateable value or where there is a meter, by volume consumed. If metering is not used there is a flat fee, which is proportional to the price of the valuation of the domestic property. Since ninety per cent of domestic consumers do not have a meter they are charged in this way. The Government and the regulator are keen to encourage alternative methods of charging. Since 1990, when the domestic rating system ended, most water companies have used meters as the method of charging newly built properties which have never been assigned a rateable value.

Vignette VI

Metering is often regarded as the fairest way of charging each household for water and sewerage services. The reason why meters are not used at present is that the cost of installing them makes them uneconomic, except for new homes or when water services to a household are being overhauled. Most commercial and industrial customers are metered already, and all households can opt for a meter

to be installed at their own expense. There is a standing charge to cover the fixed costs and a price, which is proportional to the volume of water consumed. This is applied to domestic consumers who have meters, and to most industrial consumers. Many industrial companies also use water that is treated but not drinkable. The cost is generally split about fifty/fifty between water supply and wastewater. In 1994/95 the average bills for customers with meters were £96 for drinking water and £102 for sewerage. There are also a number of rules that water companies have to apply when they are setting their rates. One is to do with what a water company can charge its customers which is known as 'the differential'. This is a fixed relationship between the average tariff for a measured, and the average tariff for an unmeasured customer. It is a tariff basket, which ensures that companies are not discriminating unfairly between customers who are metered and customers who are not metered.

(Source: Interviewee: Ronnie Yellon, Anglian Water)

Due to the low penetration of metering, it is now clear that rateable value charging will not be abandoned in 2000. Two alternatives to metering are available, either a tariff for a zone of habitation or a uniform levy for each source. Ofwat has left it to each company to introduce its own system after consultation with their customers. Nevertheless Ofwat has made it clear that it prefers the installation of water meters.

Vignette VII

The debate about the merits of metering within companies continues:

"I think in tariffing in the future there will be more segmentation e.g. more tariffs based around lifestyle packages. I happen to think that the psychological contract between the organisation and the customer is different under a metering relationship. That means that you can develop a number of tariffing capabilities."

(Source: Interviewee: Ronnie Yellon, Anglian Water)

10.3.3 Metering and the Environment

Since privatisation environmental factors have become a dominant feature. As a response to the drought of 1995-96, The Department of the Environment published its Water Resources and Supply, *Agenda for Action.* The report covered inputs from the Government, The Environment Agency, Ofwat, the Regional Water Companies, manufacturers and customers. It also recommended an extended introduction of metering, the development of more sophisticated tariff structures, to further consider customers' security of supply and to take every opportunity to use water wisely.

Since the 1995 drought some mandatory measures have been taken throughout England and Wales. Everyone using a sprinkler watering system and/or who has a swimming pool has to have a water meter installed. Supplementary levies, and even compulsory metering, are operated in some areas for the use of hose pipes as well. There is also a potential benefit (at presently unrealised) for separately metering hoses and sprinklers. By definition hoses and sprinklers should incur no wastewater treatment costs if cost reflective pricing is taken to its inevitable conclusion. On the other hand reducing the cost of garden watering does not encourage the reduction in demand nor seems socially desirable.

The key area is how you pay for the growth in the demand for water. The Department of the Environment has promoted a methodology for paying for investment. That is to say that all the balancing of supply and demand has to be on an optimised basis. The Ofwat approach meanwhile is to say that you are very unlikely to get money for investment on new capital resources until you have demonstrated that you have looked at all the other elements in the operational mix (Ofwat, 1996).

Vignette VIII

"Ofwat is currently very interested in the principle of long run marginal costing but the practical reality today where you do not have sufficient metering penetration it is a little bit like 'Alice in Wonderland' really."

(Source: Interviewee: Ronnie Yellon, Anglian Water)

The environment is more fundamental in water than in energy so a key player in the water industry is the environmental regulator. Nevertheless, some WSCs feel that the role that the Environment Agency plays is a rather ambiguous one. The Environment Agency's *raison d'être* is different to that of the water companies, Ofwat and even the Drinking Water Inspectorate. The EA's purpose is to protect the environment for everyone (recreation, wildlife etc.) often laid down in European Rules. This infuriates some water company managers:

"In our research to find out what customers want we (the WSCs) try to produce a balanced process, but we have a lot of obligations, which have nothing to do with our customers' wishes decided for us by Brussels. There is a little bit of a political deficit there."

(Source: Interviewee: Ronnie Yellon, Anglian Water)

Nevertheless when it comes to metering the Environmental Agency backs its development particularly with regard to demand management and water conservation issues.

10.3.4 The Social Implications of Water Metering

A number of studies have been carried out to discover whether increased metering penetration would endanger vulnerable customers (Ofwat, 1992 and *The Utilities Journal*, 1998). It turns out that most socially vulnerable customers benefit from lower bills if sensitive 'time of use' charging is imposed, compared to the present system based on rateable value. Although, clearly some households with medical conditions such as renal dialysis and incontinence are adversely affected. So it is suggested that cross-subsidies in water tariffs or the social security system would be needed protect some customers.

Another social issue is the possibility of installing prepayment metering for water consumption. This is widely used in the electricity and gas industries (see sections 6.3.6 and 8.3.4) but there are concerns about household hygiene if such devices are used in water. Indeed the Water Consumers' Council (WCC) still have reservations over widespread metering. It suggests that more money should be invested in water saving appliances. For example, in the UK the average toilet flushes 9-13 litres compared to 3 litres in Singapore. Improvement in areas such as this, it is claimed by the WCC, should take preference over metering.

10.3.5 The Management of Meter Operations and Data Collection

The low level of meter penetration means that the concept of a meter operation and data collection function is not yet 'up and running' in water as in electricity and gas (see sections 6.3.4, 6.3.5 & 8.3.5).

There are two things that make communications in the water industry unique. Meters are usually outside customers' premises in a hole in the ground and often they are some distance from a power source for electronic communications. In addition, out of all the utilities it is particularly water managers who see that data collection is not part of the core business in water.

Vignette IX

"Obviously the electricity model is one of hiving off the meter reading process from the core business and placing it for competitive tender. That does not

happen in the water industry, partly because there are not enough metered customers to make it a viable model at the moment. If there was universal metering that would be a model that a regulator would consider and bring into force by legislation. The feeling is that it may happen in the long term, but it is unlikely within the next five to ten years, because there are not enough meters on the ground."

(Source: Interviewee: Steve Marjot, Anglian Water)

Nevertheless water companies have certain advantages when it comes to meter operation. Since they do not have a large meter operation function, they are looking at meter operation and data collection with fresh eyes:

"You see they have nothing to lose, since metering penetration is so low there is not a stranded assets problem. A lot comes down to the culture of the company and what the company see themselves as. Someone like Yorkshire Water have just gone out to tender for meter reading services. Other companies such as Severn Trent Water have now contracted out of meter installation, pipe work and billing. Then you have got other companies (WSCs) who take the view that there is no way that they will out-source their metering services."

(Source: Interviewee: Craig Howarth, ABB Kent)

10.3.6 Electronic Metering and Communications

Electronic metering and automated communications systems are still in their infancy in the water industry. During 1999 Anglian Water intend to install ten thousand Automatic Meter Reading (AMR) modules using the 184MHz radio wave band. In this plan there are two key technological partnerships. One is with the water metering company ABB Kent. Although the initial meters being installed are purely mechanical, at a cost of £18 a piece, Kent are in the process of developing a 'solid state' meter. The second partnership is with the software company Logica. Logica is the developer of the communications side of the AMR system. Most of the AMR devices use touch read systems (see Section 12.4.2). In water meters all that is required is an inductive meter so that batteries on the water meter are not needed. Another reading probe is placed up against the inductive pad, and it supplies the power to the meter for the time that it is being read.

Vignette X

Components of Anglian Water's business case for the development, run in five strands: service to customers; improved revenue management; competitive advantage; demand management; and operations management. Also Anglian see that many information technology systems such as the billing and customer service, asset management, work management, tariffing, and distribution automation systems need to interact with AMR. Anglian Water have forecast that the AMR solution is thirty-seven per cent cheaper over a net present value of twenty-five years.

(Source: Interviewee: Keith Edwards, Anglian Water)

In general, metering technology in water uses simple mechanical devices but there is a 'solid state' meter on the market for domestic customers. A company called Fusion, owned by Severn Trent Water has developed this and some water companies are testing them. Fusion meters have a 'touch read' system called *Talisman* and they are fitting those at a rate of about 3,000 a week. Hand-held technology has been used successfully in Yorkshire for the past seven years and has been based on Itron (a communications software company) equipment. Currently the *Talisman* meter reading system from Fusion is one of the few capable of 'touch' reading meters from multiple manufacturers while Ramar, in Europe, has the largest share of the low power' radio-based Automatic Meter Reading systems.

(Source: Interviewee: Bob Sheldon, UKAMRA)

10.4 SUMMARY

There is very little prospect for a competitive market developing in water. Therefore the decision to privatise the industry in 1989 was primarily a political one, namely, to divert investment from the public to private sector. Price regulation by 'yardstick' competition does present some buffer to monopolistic practices. However the major concern regarding the regulation of the water industry in England and Wales is its centralised nature and lack of local democratic accountability either in the economic, social or environmental sphere.

Metering in water will continue to increase. There will be about 30 per cent penetration in households and 95 per cent penetration of non-households in five years. The key issues are fairness to customers over pricing, demand management and the environment. The decision that cost reflective pricing should replace rates as the basis for setting prices is crucial to the development of metering. Most of the pressure to install metering comes from the economic and environmental lobbyists while consumer committees are yet to be convinced of the merits of metering, over the installation of water efficient appliances. It seems that some form of hybrid system based on consumption for customers with meters and one on a flat fee for those without meters, will continue for some time.

With respect to automation, the water industry presents tremendous opportunities. Since new meters are being installed, additional features can be developed at marginal cost. Here there is an opportunity for multi-utility metering and even multimedia linkups.

CHAPTER 11

CASE STUDY No.6:

WATER IN FRANCE

11.1 INTRODUCTION

With 57 million inhabitants occupying over half a million square kilometres, France is completely self sufficient in water resources. With high mountains, important underground aquifers and long rivers, water plays a key role in the French economy. Sixty per cent of the rain evaporates and the rest flows out in rivers. Of this, two thirds flow out steadily and one third in floods. In effect, France has around 100km^3 per annum of water that is largely at its disposal to cover the consumption needs for its population. The circulation from neighbouring countries is relatively insignificant with 14km^3 entering (chiefly the Rhône basin), and 16 km^3 leaving, the French borders. However, the volume obtained from Belgium is vital for the Artois-Picardy region. These figures exclude the Rhine, which represents 30 km^3. This resource is of little importance to France but is essential for Germany and the Netherlands (Barraqué, 1995: pp.111-112).

This rich resource has regional variations. In Brittany for example, the presence of granitic rock types prevents underground storage, thus presenting problems associated with soil erosion. By contrast, the Mediterranean regions are dry, while the South-West requires extensive irrigation. There are also urban requirements, such as the Parisian region that derives most of its water and sewerage needs from the Seine, which is a relatively small river. It is therefore necessary to obtain supplies from neighbouring river courses such as the Eure and the Loire. Thus, water conservation is an important factor. This case study will first consider the French water infrastructure and its regulation. It will then go on to examine the role that metering technology plays in the management of the industry.

11.2 INFRASTRUCTURE

11.2.1 Historical context

In France, the right for water is derived from Roman Law. In the Renaissance and the époque classique, water resources were split into four categories: closed water (lakes and reservoirs); underground water resources; running water which was used for commercial transport; and running water which was used for domestic and communal consumption. After the industrialisation of the nineteenth century, laws enacted in 1898 and 1935 imposed tighter restrictions on the roles of each party in relation to the use and disposal of water. The rights of different parties using water resources for different means were defined. For example, industrial, transport and recreational uses were recognised, and compensation for the infringement of others rights was developed. So the notion that the polluter pays, is substituted in France by a notion of communal solidarity administered by the State. In general, it is viewed that water is inappropriate for private ownership, but the management is placed in private hands. This is not to deny that there have been pressures on the system over the years. Evidence of this is that further Laws were enacted in 1964 and 1992, and these have recognised the increasing diversity of water usage and environmental needs. Water quality targets for each watercourse have been developed and the co-ordination of the users of the water systems has been introduced. The theme to this continued evolution is that water resources are seen as a common heritage for the nation, and the power, if at all possible for their maintenance, should be left in the hands of the local communities (Barraqué, 1995).

11.2.2 Regulation

France is a centralised democratic republic with a regional representation. In other words, in principle the municipalities retain a lot of sovereignty, but at the same time they have not always the means to carry out their economic or environmental plans. This historical tension has resulted in both central and local management of water and intermediate liaison between the ninety-five mainland départments. In another respect, there is very good clarification of the notion of historic public service which permits the delegation of the operation of these facilities to private companies thus introducing the rigour of business methods and above all, supplying the expertise of water engineers. This decentralisation is marked by a durability and security of supply, which has a mixture of local accountability and private enterprise acting within the framework of the State (Barraqué, 1995).

The structure of the French water industry is somewhat complicated by a demographic and geographic split between the management of water, namely the administrative region and the drainage basin, both of which may cover different overlapping areas. The day-to-day operations is the responsibility of the Local Authority while central co-ordination is carried out by the State under the direction of the Department of the Environment. This department is responsible for the advising the regions about water management such as conservation of aquatic life, water quality and pollution control, as well as international co-operation and judicial affairs (Ofwat, 1997a; Barraqué, 1995 and DTI, 1990).Under the direction of the Ministry of The Environment (DIREN) the Services Régionaux d'Aménagement des Eaux (SRAE) are responsible for setting minimum quality standards on wastewater, drinking water and bathing beaches. Although responsible for setting standards they are not responsible for policing these standards which is left to the DIREN itself. The system has the advantage of being close to the ground in that it is administered at a local level but it tends to lack rigour particularly in policing. For example, there are only 600 inspectors for 550,000 water establishments of which only 150,000 are the responsibility of the Ministry of the

Environment. The remainder are the responsibility of the Ministry of Industry (DRIRE) and the Ministry of Agriculture. The Services d'Assistance Technique à l'Explotation des Stations d'Épuration (SATESE) inspect the purification stations and this function accounts for significant expertise employed by the State. Indeed the State has subsidised a lot of the improvement in water purification in the past. But, since 1975 the State has taken less interest, insisting that the financing of projects should be derived from the users of the facilities. Nevertheless the Fonds National Pour le Development des Adductions d'Eau (FNDAE) is present to fund any non cost effective projects, especially in rural areas. With the quality of water having been gradually improved over the past twenty years particularly in the reduction of urban pollutants, attention now has spread to pollutants caused by agro-fertilisers. Contamination of ground water by these fertilisers is a significant problem in places like Brittany (DTI, 1990).

To oversee the environmental regulation of a drainage basin as a whole, *l'Agencies de Bassins* (AdB) were created in 1964. These groups recognise the need for some administration on a geographical basis and work a non-coercive basis with the Local Authorities. There are six authorities; Artois-Picardie, Sein-Normandie, Loire-Bretagne, Rhin-Meuse, Rhône-Mediterranée-Corse and Adour-Garonne. They are made up on a tripartite basis: consisting of users' representatives (Domestic, Industrial, and Agriculture); Public Authorities; and the different levels of administration both public and private. To supplement this, there is a President for each of L'Agencies de Bassins who is appointed by the State. They are concerned with issues that affect the entire water system and they adopt a five-year programme of action. They are neither responsible for policing the system (like the environmental authority in the UK) nor overseeing capital expenditure (as in some parts of Germany). In France these issues are seen as responsibilities of the State. They are the administrative body that lies between the Local Authorities and the State, and they co-ordinate the pollution standards and decide on matters of water consumption and payment. In the traditional French republican method of governing, the standards and rulings are arbitrated for, and legislated at, State level. The funding of the AdB is achieved through the collection of a levy on the abstraction of water and the final price of water charged to domestic and industrial users. On planning, the Agencies are required to devise programmes for the best use of water resources, through a system of data collection, which includes demographic as well as technical resource surveys. The Agencies advise communities (of all sizes) on their proposals; but they are not responsible for the award of contracts, this responsibility, which rests with the community or business on whose behalf the work is being carried out (Barraqué, 1995 and DTI, 1990).

Vignette I

The AdB actions are limited due to the lack of their legislative power. For example, the needs of Electricité de France and the large amount of water required in its nuclear and hydro-electric generation programme are outwith their scope. The AdBs are therefore often subjugated by other interest groups such as Industry or Agriculture who have direct links with the Government. Below the AdBs are found the water supply and sewage treatment authorities. These are the Local (i.e. municipal or départmental) Authorities, which normally manage the water supply system on a day to day basis. This is usually done directly, but some authorities will contract the management out to private companies.

The procedure for deciding on new works involves both the Local Authorities and the AdB. The Agency, on the advice from other bodies (such as those supervising agriculture or housing) will consider the needs of a community within its area; proposals are then discussed with the municipality. The mayor or municipal committee, having taken independent advice, then decides if the work should go ahead. This would then go out to tender by the municipality. Bids are considered on a technical basis (subject to advice from the Agency, consultants and from the other bodies mentioned above) and on a commercial basis, taking into account

factors introduced by the client; these will normally include consideration of other funds available.

(Sources: Interviewees: Jean Gasc, SLE; Lisette Provencher, SLE; Frank Texier, CGE; Jean-Louis Ganion, CGE and Françios Paquet, CGE)

The most important development in legislation is the recognition in recent years of a balance between economic and environmental uses and the emergence of an integrated plan. The 1964 law recognised the need to act against pollution and impose quality standards. With a law enacted by the French Parliament in 1976, the protection of nature became a priority in that any economic development required a detailed consideration of the environment. In 1984 there was a fishing law which considered the migration of fish and the need of industry to take account of this. A further law enacted in 1987 detailed the insurance requirements for natural catastrophes such as inundations and floods. Finally after many years of preparation, the law in 1992 brought together many of the themes developed over the past thirty years. It involved the amount of water that could be extracted, the amount to be paid and whether it was for private or communal use. It defined zones of autonomous purification and where purification has to be carried out by a number of Local Authorities. It also tightened the guidelines for prosecuting local mayors for illegal pollutants (Barraqué, 1995).

11.2.3 The Public Municipalities and the Private Companies

In France, like nearly all countries in Europe, but unlike the UK, the local public authority is responsible for water supply. The authorities are large in number and are very small in size. It is these 36,400 communes who are responsible, or more accurately the local councillors, who are responsible for water supply and waste treatment in France. These originated from the old parish councils, 'sociétés de citoyens', which were transformed into communes in 1793 after the Revolution. Of the 36,400 communes in 13,500 administration districts their water supply is autonomous, while the remainder are consolidated into around 2,000 inter-communal syndicates. Many of the small municipalities cannot support the costs of water resources, therefore they associate in syndicates or delegate to private companies. The latter have formed a professional association, the Syndicate Professional des Distributeurs d'Eau (SPDE). What usually happens is that each municipality associates in a syndicate and then the syndicate delegates to a private company. Another reason for consolidating and contracting out is technology. Small municipalities cannot afford to spend money on research and development and relying on a private operator means that you are relying on a strong engineering and business structure. Nonetheless the notion of local public accountability is of prime importance in the French water industry. This contrasts with the more centralised approach to the supply of gas and electricity (see chapters 7 and 9). Thus it is the communes themselves, not Central Government, who decide whether to operate their own water authority or to subcontract private companies to operate their facilities on their behalf (DTI, 1990).

One of the characteristics of the French water industry is the existence of large private groups who invest in capital expenditure and manage and run the facilities on behalf of the Local Authorities. The comparison with the rest of Europe is striking. Although the major conurbations such as Paris, Lyons, Toulouse, Lille/Roubaix/Tourcoing all have their own municipal supplies, around seventy per cent of water supply, and around forty-seven per cent of sewage treatment in France is operated by private sector firms (DTI, 1990).

Vignette II

"It is not a franchising out system of regulation," water company managers insist, "we are a large subcontractor who supply many communes and syndicates. In our mind it is not deregulation." The municipalities and syndicates create committees containing different interest groups. Nevertheless one factor is of prime importance and that is: "the municipality must have a balanced budget for water."

(Source: Interviewee: Jean Gasc, SLE)

For the seventy per cent of communes or syndicates who contract out their water supply there are many forms of contract.

La concession **is the full delegation of all work which includes operation and capital investment of water supply and waste treatment. A long length of time, (a contract covering twenty to thirty years) is usually needed to cover the repayment of all the capital investment. At the end of the stipulated time period the capital assets will be the property of the municipality:**

"There are very few contracts like these in France, maybe only about three or four."

(Source: Interviewee: Frank Texier, CGE)

The most common contract is ***l'affermage.*** **This is for a contract for about twelve years. The private partner is responsible for supplying water to the customer and in some cases wastewater treatment. Meanwhile the municipality has to pay for any capital expenditure and the customers pay for these facilities out of their Local Authority rates. Most** ***affermage*** **involve the private water company sending and collecting bills directly to and from the customer.** ***La jurance*** **is a type of** ***affermage*** **where the water bill is paid by the municipality to the private company.** ***La régie*** **is the name given to the water authority where the facilities are run by the municipality.**

Some contracts are a mixture of the above:

"La régie intressé **is an example of a contract in the Parisian region which is a mixture of everything. In fact it is a cross between** ***l'affirmage*** **and** ***la concession.*** **The difference is the financial instruments used in paying back investment in capital projects and operation of the system."**

(Source: Interviewee: Frank Texier, CGE)

Table 11: Market Share of Water Supply in France

Operator	Per Cent
Compagnie Générale des Eaux	36
Suez-Lyonnaise des Eaux	18
CISE-SAUR (Groupe Bouygues)	16
Total Operated in the Private Sector	70
Total Operated in the Public Sector	30

Source: DTI (1990)

Table 12: Market Share of Water/Sewage Treatment in France

Operator	Per Cent
Compagnie Générale des Eaux	22
Suez-Lyonnaise des Eaux	16
CISE-SAUR (Groupe Bouygues)	9
Total Operated in the Private Sector	47
Total Operated in the Public Sector	53

Source: DTI (1990)

There has been a major rationalisation of the private water companies over the past ten years. In 1990 there were five water companies, today there are three water companies in France. Compagnie Générale des Eaux (CGE) is the largest, with around 36 per cent of the water supply and 25 per cent of the water treatment market. The second is Suez-Lyonnaise des Eaux (SLE) with around 18 per cent and 16 per cent of the supply and sewerage market respectively. CISE-SAUR a subsidiary of Groupe Bouygues is the third supplier with 16 per cent and 9 percent of the respective markets. Tables 11 and 12 show the relative market shares in water supply and wastewater treatment.

Compagnie Générale des Eaux (CGE), is the ultimate multi-utility. As a group it consists of over 2,000 consolidated subsidiaries, who all serve the needs of Local Authorities. It is the biggest of its kind in the world. The group operates in eight sectors, water and waste-water treatment, energy, waste management, passenger transport, building and construction, urban and property development, communications and health-care. Its subsidiary, Omnium de Traitements et de Valorisation (OTV), designs, builds and operates water production and wastewater treatment plants both in France and abroad. The group has four major subsidiaries in the UK, Three Valleys Water Services plc (formed in 1991 by the merger of the Lee Valley, Colne Valley and Rickmansworth water companies), North Surrey, Tendring Hundred and Folkestone and District. CGE also have interests in the energy and communications sectors in the UK (Barnett, 1996).

During the nineteen-nineties Lyonnaise des Eaux diversified like CGE into public services. Lyonnaise des Eaux, formally a public limited water and environmental services company, merged with the construction group Dumez in 1992 to form Lyonnaise des Eaux-Dumez. This company then merged again with the Belgian public service giant Suez, to form Suez-Lyonnaise des Eaux (SLE). Lyonnaise has greater representation abroad than CGE, with interests in Spain, the United States, the United Kingdom, Italy, Germany and of course Belgium. It has stakes in over forty water distribution companies, some fifteen water treatment companies and over 40 wastewater treatment companies. Lyonnaise des Eaux operates 15 regional centres in France, and in the UK owns the Essex and Suffolk Water Company, North East Water, and Northumbrian Water. SLE's other interests also include the supply of energy to the municipalities of Grenoble, Monaco and Strasbourg (Barnett, 1996).

CISE-SAUR is the third distributor and has its major presence in the small rural villages of the South-West of France. Groupe Bouygues, which is a public works company, formed CISE-SAUR during the nineteen-nineties by combining a number of the smaller water companies in France. Founded in 1933, SAUR (Société d'Aménagement Urbain et Rural) joined the Bouygues Group in 1984 and in 1997 Bouygues and SAUR acquired an eighty per cent stake in CISE from Saint-Gobain. SAUR's interests in the UK include Mid-Southern and South East Water (Barnett, 1996).

Table 13: French Interests in UK Water Companies

French Company	UK Company	Stake %
Compagnie Générale des Eaux	Bristol	30
	Folkestone & Dover	74
	Mid Kent	20
	North Surrey	99
	South Staffordshire	30
	Tendring Hundred	90
	Three Valleys	100
Suez-Lyonnaise des Eaux	Essex & Suffolk	79
	North East	80
	Northumbrian Water	100
CISE-SAUR (Groupe Bouygues)	Mid-Southern	100
	South East	100

Source: Barnett (1996)

11.2.4 Environment

The water industry in France currently faces a number of environmental concerns. Solving the problem of denitrification is expensive and not fully effective on a large scale. In 1984 (the latest available report) analysis showed that whilst the number of users taking water with more than 100 mg/l of nitrates had been reduced, the number of rural users affected by concentrations of between 50 mg/l and 100 mg/l was on the increase (DTI, 1990).

The extent of micro-pollutants - oil deposits, organic and inorganic chemicals, heavy metals etc. - found in some water courses is also high. Despite serious attempts by industry to control waste, it does from time to time cause a serious hazard to water supplies. Coastal water pollution also presents a problem to the French authorities; the Ministry of the Environment favours land-based treatment of wastes or a pipeline extension system (pumping waste into deeper water currents) to replace the present widely used system, of pumping waste onto surface water too close to shore (DTI, 1990).

Perhaps the most significant environmental issue is the seemingly low level of sewage treatment - which according to some figures averages, on a nation-wide basis, 34.5 per cent. This figure can be somewhat explained by the feature that France is a more rural population than some of its near neighbours. The low density in population also means that France has the highest number of septic tanks in Europe and the highest number of water treatment plants (more than 12,000). Some progress has been made on this with the recent completion of wastewater treatment systems for the Mediterranean coastal towns; but no statistical evidence is yet available to show that an improvement in a traditionally bad area will significantly alter this percentage (Barraqué, 1995).

It would seem that much remains to be done. Investment in equipment for the water supply industry steadily fell during the nineteen-eighties when the proportion of the water industry's share of public works has fallen from 19 per cent to 15 per cent. But the introduction of European standards, the need to further extend the network of sewage collection, and the need to replace ageing equipment (a large percentage of installations were completed in the five years following the AdBs' creation in 1964) has resulted in increased investment during the nineteen-nineties (DTI, 1990).

11.3 METERING

11.3.1 Abstraction Charges

There are three classes of water meters in the supply chain in France. These are production water meters, distribution water meters and the customers' water meters. Water initially has to be abstracted from a source, which is usually an underground aquifer or a reservoir. There are production water meters at this point and all suppliers have to pay a levy for abstraction which goes to fund *l'Agencies de Bassins*. Once the water is abstracted it goes through a water treatment plant, then into a storage tank where distribution meters meter the water. The water is then supplied to the customers' premises where it is again metered. Usually the meter position is outside the house. In some instances there is one meter for one property, but often in France there is one communal meter for a block of flats. In the latter case the bill is sent to the administrator of the services to the flat who pays the account for all the residents. The administrator then charges each individual their share (Ofwat, 1997a).

Most data about water demand are derived from the volumes abstracted, which all water users of a basin have to declare to their AdB. Since the 1992 water law, all ground water abstractions above 8 m^3 per hour must be declared. Agencies check the users' declarations through surveys and through site visits (meter reading). Funds and personnel allocated to controls are however, very limited. In France, metering is generalised at the property level, for industry and for drinking water. Abstraction data that come from water utilities and industries are thus rather imprecise, while those concerning farming are even less accurate. Many small farmers who irrigate have not yet installed a meter, nor do they declare their water intakes.

Vignette III

Abstraction charges, which help fund resource protection programmes, are levied. Also, reducing leakage can reduce abstraction charges:

"There is a peculiarity in France for irrigation. In the past, farmers who sink boreholes in their fields for the exploitation of water were not monitored. So the AdBs now give a seventy-five percent grant to install metering to electronically monitor this. There is also a strategy for the replacement of production water meters every seven years. L'Agencies de Bassins want to have good water meters. So if abstractors do not change these meters after seven years then they are liable to a tax."

(Source: Interviewee: Françios Paquet, CGE)

11.3.2 Pricing

Since public supply is decentralised in France, both in terms of distribution units and in terms of economic control, very few centralised data exist on water price structures and levels, and on technical description of existing infrastructures (including level of leakage). Sanitary control of water utilities is organised at the scale of ninety-five French metropolitan départments (plus five départments overseas), by the field services of the ministry of public health. So centralised data in that field are also rare. Data from the Syndicate Professional des Distributeurs d'Eau (SPDE) are also not accessible to researchers. Concerning public supplies (covering the remaining thirty per cent of the population), the situation is even worse, since there are no national statistics available. Some data about all undertakings (private and public) can be derived from the office of the Ministry of Agriculture who manage les Fonds National Des Adductions d'Eaux (FNDAE) tax. Through the collection of that tax, the ministry keeps a record on all the public water supply undertakings in France (DTI, 1990).

Table 14: Water Supply by Sector in France (1994)

Sector	Millions of Litres Per Day	Per Cent
Public Water Supply	16,249	15
Industry	10,833	19
Power Generation	70,723	63
Agriculture	13,619	12
Total	111,424	100

Source: Ofwat (1997a)

Table 15: Consumption Patterns in France (1994)

Per Capita Consumption (litres per household per day)	152
Leakage per Domestic Connection (litres per connection per day)	222
Length of Mains per Domestic Connection (meters per connection for 10m supply pipe)	53
Length of Mains per Domestic Connection (meters per connection for 5m supply pipe)	48
Approximate Population per Domestic Connection	4.4
Metered Households	99 Per Cent

Source: Ofwat (1997a)

FNDAE and SPDE statistics do not give a detailed breakdown of the volumes abstracted by various categories of users served. They usually first distinguish between raw water sales and drinking water sales. For drinking water sales, only two categories of users are separated, customers using more than 6000 m^3/year are called 'big customers' (gros domestiques). 'Big customers' include large social housing buildings (with many flats connected to one meter), which are residential users. Conversely, domestic customers include small businesses, commercial activities, minor farming and individual users. The lack of more detailed data on water demand comes from the commercial status of water suppliers. For instance, this status forbids them to sell quantities of potable water at different prices to two users of a different type (i.e. an industrial premises and a large condominium would get the same rebate if they are in the same category of users). The suppliers have never yet felt the need to survey the detailed demand of various types of users, and their national statistics separate only 'large' and 'small' users. There may be more precise data available here and there, but they are not recorded at centralised levels. Tables 14 and 15 show water supply and consumption patterns by sector.

Vignette IV

The French definition of 'domestic customers' is therefore very different from the definition of 'residential customers' in UK analysis. This is a source bias for international comparisons of factors influencing the 'domestic' component of public utilities water demand. Another methodological issue is the importance of secondary summer homes in France, some of which are rented or even owned by foreigners. This does introduce a bias, since France is one of the first countries in the world in terms of tourist attraction.

Almost all households are metered. Eighty-eight per cent of households (100 per cent single family homes and 75 per cent flats) are metered individually. Domestic meters have a lifespan of between fifteen and twenty years:

"A hundred years ago there were no water meters in France, then there was a permanent flow-rate that was supplied. If you look at archaic water systems, it is always the flow rate that was regulated, not the volume. It was supplied in channels or pipes and divided up by splitters. This is still used in some Mediterranean countries. This method was also used in England. A permanent flow rate was supplied and there were regulating valves to fill tanks. But now that we have public tanks it is not necessary to have tanks on the roof, but if you go to Mauritania for example they still have tanks and of course they also do in the UK."

(Source: Interview: Jean Gasc, SLE)

The predominant metered charging structure is a standing charge plus a volumetric charge. Alternatively there is a standing charge plus a flat fee for a given volume plus a volumetric charge for the volume exceeding the quota (this applies to about fifty per cent of undertakings). The type of volumetric charge is either a uniform rate or decreasing block tariffs for households. The standing charge is between zero per cent and ninety per cent of the total metered bills (DTI, 1990).

Vignette V

"There is usually a different fixed charge between different classes of customer but the proportional price is the same. When the city accepts that a factory is of significant importance for the area it may ask for a special price. There are however exceptions, such as a golf courses who do not qualify for any reductions because they are consuming a lot of water and usually during the summertime."

(Source: Interviewee: Jean Gasc, SLE)

Only about one per cent of meters can measure flow-rate, which can be particularly useful when detecting leaks. Each municipality defines specifications for water meters. In some cases however, there may be a contract with an individual industrial customer that they have a maximum flow-rate, because if they take too much at once there is a fall in pressure on the system. So if the maximum flow-rate is exceeded the customer would have to pay penalties. Usually these private contracts encompassed the municipal's contact with the private operator. Maximum flow-rate has become less of an issue in France since demand for water is decreasing, and investment could be postponed. If demand is increasing as in the UK, the water company would like to know how different customers are contributing to that demand so that they can be charged accordingly. There is also an increasing incentive to reduce leakage since water is becoming increasingly more expensive to treat. This may give further incentives to the development of metering in the future.

Sometimes the price of water is on a seasonal basis. For example, in some rural towns where there are 3,000 inhabitants during the winter and 100,000 during the summer, there may be a different price during the summer. The municipality takes the final decision on whether there should be seasonal variation in tariffs:

"The town decides that the price will be different during the winter than the summer, to make people living permanently in the town pay for investment for people who are only there in the summertime is not right."

(Source: Interviewee: Jean Gasc, SLE)

"In some instances customers may have two connections, one for the household and one for the garden. If a customer has only one connection they pay the same price. But if there are two connections the customer will pay the same price for water supply but the lawn sprinkler connection has no wastewater charge. Also in special cases there are separate supplies for drinking and non-drinking water. For example, Gibraltar has two separate supplies but in general in France this system does not operate. In Paris, there used to be an industrial water network, which came from the river Seine, and was used to clean the streets. That has now been stopped because it is more expensive to have two separate treatment plants. Hose pipe bans and drought orders are very rare. Drought orders hit non-potable water for irrigation first."

(Source: Interviewee: Lisette Provencher, SLE)

Depending on the contract, the customer receives between one and four bills per year. For very big customers it is one per month. There may also be monthly readings for these large customers as well. The most common method of payment for domestic customers is four bills per annum, two of which are based on estimated readings. There are also flexible methods of payment, such as direct debit and budget schemes etc.

For the moment, the majority of meters are read manually:

"People are experimenting with portable hand-held terminals, so they see if there is a good correlation between the last meter reading and the next one. So the water company can estimate the consumption by previous readings so that the

number of times the meter requires to be read can be reduced. There are no prepayment meters and it is difficult to cut someone off, since that would be considered socially unacceptable in France. With respect to customers who are unable to pay, the cases are discussed with the municipality and the social security."

(Source: Interviewee: Françios Paquet, CGE)

The issue of metering in France is not the installation of meters, as it is in the UK. It is the issue of using metering to best manage the water resources. So the relation between metering and the environment is more of a financial one. If someone wants to use a lot of water they will have to pay a lot, but there are no such restrictions in the UK.

11.3.3 Electronic Metering

Electronic metering in the French water industry is given a low priority. The problem with electronic meters and automated meter reading in France is two things, the law and the cost. At the moment the water industry is restricted to simple mechanical water meters because there are no agreed standards. Or more precisely, there are agreed standards for electronic metering but not for communications. This seems rather odd from a British legal perspective which is based on the principle that if there are no standards then there is nothing stopping entrepreneurs from developing a product that will create a standard. The French however, see that standards must be firstly created and enshrined in law before production can commence.

Vignette VI

"There is no point in starting production of an electronic meter if Itron (a software company) come up with one standard, Schlumberger (a meter manufacturer) another and Lyonnaise des Eaux yet another. So we need a language of protocol standardised."

(Source: Interviewee: Françios Paquet, CGE)

"Work is being carried out on a European level to develop these standards. Water companies are working with Electricité de France and Gaz de France along with other utilities throughout Europe. This work not only includes metering but other areas of home and office automation. It is only when these European standards are approved that all the old systems will begin to be replaced. The problem is that every manufacturer is looking to create their own proprietary standard."

(Source: Interviewee: Jean Gasc, SLE)

These committees which are concerned with standards and protocols for electronic metering are described in section 12.4.8.

This strategy of agreeing standards before starting production is diametrically opposed to what is being seen in the UK and USA. In these countries, proprietary standards develop through market mechanisms rather than political agreements. The issue of the necessity of the secure flow of confidential information for each of the utilities is cited as one major reason why common standards have to be agreed before progress can be made. The following statement from a senior manager in a large French water company sums up the mood in the French water industry:

"We have nothing to say until the standard is agreed. Although a standard is not compulsory to develop electronic metering we believe that the standard will be so easy to use that everyone will want to use it, and not a proprietary system. Itron for example has a proprietary system and they are trying to make it the standard. But of course, we are refusing to be any part of this."

(Source: Interviewee: Jean Gasc, SLE)

Despite this, electronic and automated systems are being tested, so as the companies say: "we know, what we can do." Experiments are being tried with radio, and telephone systems and electronic meters with can additional functions such as flow rates are being trailed. Each project has to get approval from the Ministry of Communications, since each country has regulations for modems and bandwidths. Also despite the reticence of French companies to introduce proprietary standards software and low power radio, companies such as Itron and Ramar have a strong presence in these projects.

Vignette VII

Many managers in the French water industry also see a very strong economic argument for not investing in water metering. This is particularly true for water meters that do not have their own in-built power source:

"When an electronic logger is attached to a water meter it is very very expensive. So for the moment for economic reasons it is better to wait a little time... To summarise, there has been a lot of work done on the matter so the technology is pretty well known. It is now recognised that the real barrier is cost because it is typically very expensive."

(Source: Interviewee: Françios Paquet, CGE)

Thus at present it is only with large water consumers who are billed on a monthly basis that automated electronic meter reading is deemed economically justifiable:

"We (a water company) have some niches where automated meter reading is economical, for example we have some large customers in the centre of Paris who need to be read once a month. But these are special cases."

(Source: Interviewee: Jean Gasc, SLE)

Another area where there is an apparent niche for electronic metering is in water abstraction. Abstraction of water in France is illegal without a licence and any abstraction must be closely monitored. There are two things. First, there is a very powerful agricultural lobby in France and there is debate, both about the amount of water that needs to be abstracted for agriculture, and the level of nitrates deposited. This conflicts sharply with the water industry. Second, mechanical water meters are liable to clogging with sand and farmers to avoid abstraction charges often use this as an excuse. 'Solid state' electronic meters have no moving parts so do not get clogged up and therefore are useful in reducing the illegal use of water.

Another spur for remote meter reading that is peculiar to France is that most

householders lock their gardens, making access to meters even more difficult than in the UK. Also the concept of multi-utility supply is well established. Some régies in France look after both gas and water so shared services like meter reading and billing are pooled. This is also true in the private sector where all three competitors (Compagnie Générale des Eaux Suez-Lyonnaise des Eaux and Groupe Bouygues) have telecommunications and energy supply arms.

(Sources: Interviewees: Jean Gasc, SLE; Lisette Provencher, SLE; Frank Texier, CGE; Jean-Louis Ganion, CGE; Françios Paquet, CGE)

11.4 SUMMARY

The regulatory system for water in France has been an attempt to balance the needs of small communities with the needs of large companies and the State. With respect to pollution and the environment the AdBs act at an intermediate stage between the State and the Local Authorities. The system is based on one of co-operation and negotiation, rather than the 'polluter-pays' principle as in the UK. The principle of 'delegated management' where a municipality's water operations are run by a private company has stood the test of time. Nevertheless, it still remains unproven that publicly run networks can operate at a lower price in practice. Despite this, the tendering system does introduce some market rigour and the private companies provide both financial and engineering expertise in the operation of water services otherwise unavailable to local communities.

Most water companies in France do not see metering as being a priority issue. This is chiefly because water metering is almost universal in customers' premises and it is seen as too costly to upgrade to electronic meters. The only immediate application for 'solid state' meters would seem to be in water abstraction where foreign bodies like sand cause mechanical meters to clog. Another bottleneck is in the area of standards. The French water industry is adamant that no automated metering and communications systems will be installed until standards and protocols have been agreed at political level. For this reason entrepreneurship is inhibited.

CHAPTER 12

CASE STUDY No.7:

TELECOMMUNICATIONS IN THE UK

12.1 INTRODUCTION

The telephone and the telegraph were both originally introduced in the UK by private interests in the middle of the nineteenth century. In 1912 the General Post Office (GPO) took over responsibility for the operation of telecommunications throughout the United Kingdom, with the exception of only Kingston-upon-Hull, Portsmouth and the Channel Islands. The GPO was also responsible for postal services and for the overseeing of broadcasting. Telecommunications revenues were treated as part of the general revenue of the State, along with the proceeds of taxation. Telecommunications expenditures were met from moneys voted by Parliament, along with other Government expenditures. GPO finances were legally separated from those of central Government by the Post Office Act of 1961 (Harper, 1989).

The Post Office Act of 1969 created a nationalised corporation called The Post Office, which assumed responsibility for posts and telecommunications and which published an Annual Report and Accounts on the usual commercial lines. The Corporation was wholly owned by the State, but was outside Government. Its staff were not civil servants. The oversight of broadcasting also remained a Government responsibility (Harper, 1989).

The British Telecommunications Act of 1981 enabled the Government to introduce competition in telecommunications. It also created two separate nationalised corporations - The Post Office, responsible for posts, and British Telecommunications (BT), responsible for telecommunications. Today, the telecommunications market in the UK is the third largest in Europe, significantly smaller than that of Germany, but not very far behind France. The UK has been in the vanguard of telecommunications liberalisation for more than fifteen years and is the most competitive in Europe. This chapter reviews these developments and considers how the changes have affected electricity, gas and water metering (Woods, 1997 and Harper, 1989).

12.2 INFRASTRUCTURE

12.2.1 The Fixed Network

Following the Telecommunications Act of 1983, British Telecom (BT) was privatised in three stages, with the Government offering three share tranches of 50 per cent (1984), 20 per cent (1990) and 30 per cent (1993) to the public. The first tranche was at that time the largest business privatisation offer ever made in any country (Harper, 1989).

The task of monitoring the new liberalised telecommunication market in the UK lies with The Office of Telecommunications Licensing (Oftel). Established in 1983, it is headed by the Director General of Telecommunications. Oftel's function is to oversee and regulate the activities of BT and its competitors. The effect of creating Oftel was to separate the operation and regulatory functions, which BT had inherited, from its predecessor.

Vignette I

It was argued that with relation to Central Government, internal efficiency and

the interests of the users, telecommunications is best treated as a financially and organisationally separated business activity. There were a number of reasons for this. In the first place, the objectives and priorities of Central Government structure are of their nature geared to the formulation and execution of public policy. Telecommunications on the other hand, is essentially a service industry, for which the first priority is efficiency in the conduct of technical operations. The disposition of telecommunications income is also important. GPO revenue was originally fed into the central finances of the State and GPO expenditures were met from the same source. Charges were treated as a way of raising revenue like taxation. The effect of such arrangements is to conceal the financial effectiveness of the operations of the administration and to deny to it and its customers the advantages of commercial operation, like ploughing back surpluses.

Also in an expanding telecommunications network, capital financing arrangements are of crucial importance. Proper planning and development of telecommunications is not impossible unless the enterprise has adequate and predicable capital funding for several years head. The Central Government finances of any State are inevitably subject to complex priorities, which frequently change in the short term for political, macro-economic and other reasons. This makes it unsatisfactory for telecommunications' investment to be treated as part of these finances. Personnel management considerations were also important. Whatever happens, Government personnel management has to deal with two groups of staff with special needs and constraints. The first group are the highly specialised staff who conduct the central activities of the State and support Ministers. The second are the staff who carry out administrative processes like collection of taxes and distribution of aid. If posts and telecommunications are organised as part of a Central Government, Government too must cater for their staff in its personnel practices. Unlike in France, telecommunications workers had been classified as working for a Government-owned utility, and not as a government department. As a result its personnel did not possess civil service

status, so that it has been much easier for management to reduce staffing levels quite severely over time.

(Sources: Interviewee: Stephen Pattenden, GPT and Harper, 1989)

This privatisation period almost precisely paralleled the liberalisation of the UK telecommunications industry. The first stage of privatisation was started at virtually the same time that Mercury Communications (A subsidiary of Cable & Wireless) was licensed to become the company's only fixed link competitor. This was a revolutionary step outside of the USA. This was sufficient for Mercury to complete its backbone network in the late nineteen-eighties and become established in the market. The duopoly was ended in 1992 and the regulatory powers were strengthened both to deal with the more complex competitive environment that was about to develop and to place restrictions upon BT's commercial freedom. The main elements were threefold (Woods, 1997):

- BT was excluded from using its fixed network for the purpose of transmitting entertainment material. This restriction applies until the year 2001 although, vigorous attempts have been made by BT to have this date brought forward.

- The Government let it be known that fixed link licences would be issued to additional telecommunications operators. This move allowed existing infrastructure with way-leaves, such as the National Grid Company, Regional Electricity Companies, British Rail (now Railtrack) and British Waterways, either to extend their existing networks for public use, or to build new ones. It also allowed new companies into the market to build their own (generally local) infrastructures.

- Finally regional cable TV licences were progressively offered for most of the country. These operators ware also permitted to offer telephony services. Initially these were all to be cable based, but subsequent licences allowed the use of cable, microwave or a mix of both transmission methods.

Vignette II

In most respects BT continues to be the British National telecommunications carrier. The fixed network sector for telephony is very mature, and now all but a few remote areas in Scotland are digitised. The company is responsible for more than 90 per cent of the telephone call revenues, and for 95 per cent of domestic call revenues, although the share of the international revenues is significantly smaller, and on some important routes, even a minority. Certainly BT no longer possess any *de juré* monopolies, but the combination of history and technological factors has given it very many *de facto* ones, out of which the one in the residential and small business local loop is probably the most important of all. Cable networks are also experiencing a very strong growth from a period that dates from the 1992 legislation.

(Sources: Interviewees: Peter Walker, Oftel; Stephen Pattenden, GPT and Harper, 1989)

There are however a number of restrictions to growth. The most important one is that the market is already quite mature. This is not so much in the sense that future growth will be thereby restrained, but rather the supplier structure is already developed with relatively few players at the local or the wholesale or 'carrier's carrier' market. This corresponds to Mansell's (1993) 'strategic' rather than 'idealistic' analysis of the market (see section 4.3.3). Secondly the national telecommunications operator, BT, has by now become quite a formidable competitor. It has been obliged to slim drastically, and be much more marketing and business oriented. Furthermore the tight price capping imposed upon the company for several years has greatly reduced competition directly on price. Market entry for newcomers has as a result become quite costly, with a considerable risk of failure unless a carefully considered marketing strategy is followed. For quite different reasons compared with almost all other European countries, partnerships are generally the most appropriate entry route, not for nationalistic reasons but because many existing suppliers see that they need some complimentary assistance.

12.2.2 The Radio Environment

Table 16: The Mobile Communications Market in the UK

Operator	Network Type	Start Date	Number of Subscribers, 000s		
			1994	1995	1996
Cellnet	TACS-900	Jan 85	1540	2044	1797
Cellnet	GSM	Jan 94	20	256	883
Vodafone	TACS-900	Jan 85	1520	1933	1580
Vodafone	GSM	Jul 92	118	400	1220
One-2-One	DCS-1800	Sep 93	226	397	545
Orange	DCS-1800	Apr 94	100	380	785

Source: Woods (1997)

Until 1997 the UK market for mobile cellular communications was the largest in Europe when Italy overtook it. The UK has six mobile cellular networks, four of which are digital. In 1985 the approach adopted in the UK was to licence two locally owned companies to operate the two analogue networks (TACS-900). These were Vodafone (owned by Racal Communications) and Cellnet (owned by BT who has 60 per cent and Securicor 40 per cent). This duopoly continued until the introduction of Mercury Communications *One-2-One* service in 1993 and Hutchison Telecom's *Orange* network in 1994. During this period Cellnet and Vodafone also began digital services. The UK also had the largest number of paging subscribers in Europe until 1996, when 'non-subscription calling party pays' services took off in Germany and France (Woods, 1997).

12.2.3 Network Services

Prestel was the first Videotext service, which was devised in Britain and is similar but much less widespread to *Télétel* in France (see section 13.3.4). *Prestel* is run by a division of BT but other interests provide the information on its computers. *Prestel* has developed primarily as a business service. By mid 1988 *Prestel* had a total of 80,000 customers in Britain. It also had subscribers who reach it over the international telephone network in over thirty countries. For example over 95 per cent of the members of the Association of British Travel Agents have terminals of this kind which they use to call up information about travel and hotel bookings (Harper, 1989).

Prestel can be seen as a pre-privatisation phenomenon where BT took responsibility of being the network operator as well as the provider of value added services carried on its network. Evidence is given later in the case study with *MeterLink* (see section 12.4.4) which shows that BT is moving away from such a strategy and leaving the field open to individual entrepreneurs using such media as the Internet.

12.2.4 Joint Ventures

An important spin off from telecommunications liberalisation in the UK is that reciprocity with the key US market is generally accepted. Both BT and Mercury have received advantageous interconnection arrangements with the American public switched networks. In both cases this has been made possible mainly because the US authorities accept that the British telecommunications market is largely open to their own suppliers. At the same time by giving 'carrots' to a liberalised regime they emphasise to the more recalcitrant countries in Europe some of the benefits that would become available to them once they fall into the same line. This process rapidly turns into a virtuous circle. The US remains the source of almost all the major developments in both telecommunications and computing, especially software. The country also has by far the world's most vibrant and resource rich investment capital regime. Whereas Continental Europe has tended to rely excessively upon major investments being undertaken by National Governments, either directly or indirectly, in the US the privately owned financial system provides the bulk of the funding. Nonetheless it is often assisted in basic research by a still very sizeable defence budget (Woods, 1997).

Vignette III

An important result of privatisation and deregulation is that a veritable flood of foreign capital, mainly from the USA, has been arriving to take advantage of this situation. This has been most obvious in the contraction of cable TV networks, as well as to a much lesser extent, in the provision of services and even regional fixed networks. Another closely related factor in the telecommunications business is that the country's own one time three telecommunications national champions: GEC, the former Plessey company, and STC (the latter was, however, always foreign owned) were never particularly successful. As a result they never managed to impose the same near stranglehold on the market for major hardware products such as public switches, transmission systems and attached terminals, as existed (and largely continues to exist) in France, Germany and Italy. Thus, local suppliers remark that there is a contrasting down-side to this strategy. Powerful US companies are ready and able to enter the UK market, where they can use greater financial and technological capabilities to overwhelm local companies.

(Sources: Interviewees: Stephen Pattenden, GPT and Brian Bates, AMPY)

12.2.5 Multi-Utilities

Developments in the telecommunications market are having an increasing effect on Britain's electricity companies, several of which have set up subsidiaries to operate in this potentially lucrative market. Energis is part of National Grid Holdings, two of Ionica's shareholders are Yorkshire Electricity and Northern Electric, ScottishPower has a telecoms subsidiary and Hyder (South Wales Electricity and Welsh Water) has a joint venture is with Cable Tel, a US cable television company. All of these companies are in the process of establishing some form of network, mostly cable-based, although in Ionica's case it is radio-based. In addition software companies are also showing interest in the communications in the utility sector (Woods, 1997).

Vignette IV

Novell of the US, has a startling ambition: it wants to create a massive global network by 2000. Its target is to have one billion network connections in place, at the end of 1997 there were less than 50 million installed:

"Novell is working with the power utilities to turn their electricity networks into data networks... What they want to do is to build intelligence into electrical equipment so that the companies can have much more control over their whole systems. They need to have enough to meet demand at peak times. You know what happens when there is a football match on TV. At half-time, everyone goes out and puts on the kettle for a cup of tea; electricity demand surges. But with intelligent devices, the power companies could anticipate demand. They could switch off other equipment in the home like the freezer or the central heating system for short periods."

(Source: Interviewee: Stephen Pattenden, GPT)

12.3 TELEPHONY METERING

The general principle of charging in BT is that rental and call charges should be distinct, and that each call should be charged according to its individual occupancy of the system. This is measured in terms of distance covered, the amount of plant used and the time duration for which it is in use. In accordance with these principles local-call timing was introduced in Britain in 1958, and is nowadays taken for granted by customers. Trunk calls have always been timed in the UK, as in all countries. In the UK, BT inherited a notably unbalanced structure of tariffs. The long distance calls tended to subsidise local calls. At the time of privatisation it was clear that the imbalance needed to be rectified; but it was necessary to regulate the prices to be charged by a private sector near-monopoly (Harper, 1989). This was carried out by the RPI-X mechanism described in sections 4.4.4, 6.2.2, 8.2.3 and 10.2.2. Considerable debate goes on about the appropriateness to this form of regulation based mainly on price as well as *Third Party Access* charges to BT's competitors.

Call charges can be presented on customer bills in different ways, depending on the technical arrangements for metering calls. On Stored Programmed Control (see section 4.3.3) exchanges it is possible to arrange this without significant extra engineering cost and with BT itemised bills are now standard.

12.4 TELECOMMUNICATION IN ENERGY AND WATER METERING

12.4.1 The Role of Communications in Utility Metering

Telecommunications is becoming an increasingly important part of energy and water utility metering. Some customers, particularly large industrial customers, and residential customers with large loads, benefit from more sophisticated pricing schemes. With 'real-time' pricing, prices vary from half hour to half hour, usually with some advanced notice, as in the England and Wales Electricity Trading Pool. However, the utility must have the capability to communicate with a large number of customers, spread over a large geographical area in 'real-time', or close to it. And the utility's meter must be capable of switching from one price to another and to be able to record how many kWhs or m^3 are consumed during each half hour, and at what price. The simple, stand-alone mechanical meter or an unread meter with a clock and two or three registers, will no longer suffice. The meter must have up to 48 registers (one for each half hour) and should be capable of keeping track of time accurately. In addition, the utility should have the facilities to update the prices daily and inform the customers in advance if it expects to modify their load. To implement RTP on a large scale, the utility company must not only upgrade its metering apparatus, but must also install a communications network to get the pricing information to customers in near 'real-time'. There are a number of competing carriers, for example: manual meter readers; the fixed link networks of PSTN copper wire; broadband optic fibre; electrical mains-borne signalling; as well as the non-fixed links of radio and satellite.

12.4.2 Manual Meter Reading Systems

Manual meter reading is by far the most common communication method with metering in the UK. The only exception is large consumers of electricity where communications links are mandatory. Despite this, there are efforts being made to introduce some form of low cost communication automation into the process of manual meter reading.

Inductive-Touchread technology, although not automatic, since it needs an operator to use it, is often regarded as the starting system for automated communications systems. With Inductive-Touchread technology, each of the digits in the meter has a wiper system to register the nine digits together with the serial number. They are then wired to a touch pad and inside the touch pad is a coil. Once powered up, an induced voltage is produced, waking the meter up. Software then identifies the make of meter and then it passes the serial data that is transported to the hand-held computer. The hand-held device has also a glass fibre reading just in case the customer has a query. It is widely deployed in the water industry with over 12 million installed in the USA, Europe and Australia. It has application to electricity and gas but these utilities have made only small commitments to it, primarily in North America. Its key application is to solve meter access problems being encountered today and being easily upgraded to full automation in the future. It is a robust, proven technology that requires no battery in the meters to run. Touchread can provide a fast economic return but does not provide two way communications. Many new companies are developing new products in this area. Itron for example, is a meter reading service company who sell hand held terminals as well as the software, while *Flag* and *CHIRPS* are meter reading protocols which are being developed in the UK (Woods, 1997).

12.4.3 Radio

Hand-held radio is seen by many as the emerging technology that offers the solution to many meter reading problems. Like inductive reading, it does not provide a completely automated solution until it is upgraded to vehicle, or preferably fixed network radio. These systems are now using the established 184 MHz band and around 20,000 are installed in the UK, mainly in pilot projects. There are some concerns over the performance of these systems due to limitations imposed by band specifications. However performance has been improving and the latest systems appear quite viable. Hand-held radio offers a faster reading rate, an excellent solution to meter access and a possible migration path for full two way communications. Nevertheless it is limited by the expensive equipment costs, the lack of agreement on technical standards, the range of the radio signals and battery life (Woods, 1997).

Reading meters from a moving vehicle is one of the most impressive means of reading meters, known as 'drive-by' radio. Provided that the radio system is designed to accommodate the movement of the reading equipment, very high reading rates of over

3,000 per hour can be achieved. This of course would only apply to urban areas (Woods, 1997).

An independent fixed radio network is regarded by some as the ideal solution to two-way communications. Such systems are independent of other network operators such as telephone companies and may be developed to meet specific needs. Cost remains high, and constitutes the major barrier to entry to its widespread use. Despite this, a fixed radio network has been used in the teleswitching of electricity heating appliances for many years. Just as in the hand-held terminal arena, specialist service companies such as Ramar are emerging in the private low power radio market (Woods, 1997).

Multi-utilities based on reading more than one meter per property, stand the best chance of justifying these systems. United Utilities have created a company called ENERGi and have announced that they are going to work with BCN (A Bechtel/Cellnet Data Systems International Joint Venture) to provide a radio service to all their meters right across their area.

The main competitor to Cellnet in fixed link radio is Vodafone's Paknet service, which already reads some meters in the non-domestic market. Radio-Pads are installed with each meter, and typically twenty-four hours worth of readings are collected per meter overnight. Paknet is now used by every Regional Electricity Company in the UK, and similar requirements in Gas and Water metering are fast emerging. *MeterManage* is Paknet's data communications service, which is tailored specifically for the needs of the remote meter reading and telemetry applications. The flexibility of radio removes the need to route telephone lines to remote equipment, and together with very competitive charges, can mean substantial savings in communications costs.

12.4.4 Publicly Switched Telephone Network

The fixed telephone network is the most popular medium for reading meters for large utility customers in the UK. Dial outbound systems, where the utility initiates a call to the remote meter, were the first type of telephone Automatic Meter Reading (AMR) systems to be deployed. The technology is mature, costs are stable and data rates are good for two-way applications. In many applications, a dedicated line cannot be justified and so various methods are used to prevent the customer's phone ringing when a reading is required. This, together with the need to maintain an accurate customer telephone number list has led to inbound systems finding more favour. Dial outbound is often used in hybrid systems where data is acquired from a remote data connector (*British Standards Institute*, 1998 and Southgate, 1998).

Dial inbound telephone systems, where the equipment at the remote site dials the utility on a periodic basis, are gaining ground in the world. They share all the benefits of outbound systems but have the advantage of no customer ringing, and no special exchange equipment is required. Scheduling of calls can also be automatic and these may be changed during the call-in period, ready for the next read cycle. Inbound systems may be readily installed to share existing lines or extensions from private exchanges. This, together with improvements in the provision of 'demand reads' using Caller ID facilities, has made inbound technology the choice of many large utilities world-wide. The only perceived disadvantage of telephone based systems is that the utility becomes dependent on a third party network provider for delivery of its management data. In practice it has been found that dedicated utility fixed link meter reading technology has been difficult to develop and the regular telephony network is sill being used (*British Standards Institute*, 1998 and Woods, 1997).

Vignette V

BT tried to launch its *MeterLink* telemetry service in 1995, after trials in 1994 with

Schlumberger, Yorkshire Electricity and Yorkshire Water. However BT withdrew *MeterLink* from service less than eighteen months after its commercial introduction. This was due to a perceived lack of commercial demand for the system in the present and immediate future. The *MeterLink* service was designed to enable remote polling of meters in the home from a central system. The service utilised a 'no ring call' facility to enable the meters to be read without causing the telephone to ring, and without disturbing any outbound call.

Oftel has asked BT to retain the basic 'no ring call' facility so that it could be used by other organisations such as independent service providers or utility companies. Oftel at the time BT launched the *MeterLink* service, also "had concerns about the need to provide the 'no ring call' element of the service as a separate unbundled component." Nevertheless Oftel is aware that there are other communications media such as radio, power line carrier and cable and "remain neutral" about which system should be used. However, it does "have a preference for the use of open standards" for any such systems, to enable "maximum competition in the supply of services."

(Sources: Interviewee: Peter Walker, Oftel and Haddon, 1997)

Meanwhile, users and suppliers of the technology were up in arms. They claimed that the withdrawal was "premature" and "may close the door on what is set to become a far more widely used approach, particularly as companies seek operating savings through shared meter reading." One meter manufacturer said: "We don't really feel they've given the market a chance... The problem was that it (*MeterLink*) was a store and forward system, in that BT collected the data and passed it on to the utility. And nobody trusted BT not to use it over time. They could then look at customers' profiles and 'cherry pick' those customers off the Regional Electricity Companies."

(Sources: Interviewee: Bob Sheldon, UKAMRA and Haddon, 1997)

There was also a feeling that BT was not costing its *MeterLink* service properly:

"The charges that BT were making, whether it was for gas, water or electricity were just too high. So I think they priced themselves out."

(Source: Interviewee: Bob Sheldon, UKAMRA)

"The major problem that faces fixed link communication is access. There is a problem that the meter may not be near a telephone point, and the cost of putting in a wire to the telephone could kill the technology. That is why unless we get joint utility metering it is difficult to see that going forward."

(Source: Interviewee: Stephen Holmes, EA Technology)

Nevertheless, businesses are developing in this arena using a mixture of communications media. United Kingdom Data Collection Services, Cap Gemini and Logica are key players in the development of communications in the competitive electricity and gas markets.

12.4.5 Prepayment

Many see prepayment metering (see sections 6.3.6, 8.3.4 and 10.3.2) as a developing market when it is used in combination with supermarket loyalty cards. At present in the UK there are three major types of prepayment technologies (see table 17). The magnetic strip token meter, which is like a supermarket loyalty card and is a one-way form of communications from the infrastructure supplier to the meter. The key budget meter uses a 'key' with a microprocessor on it. It has limited two way communications facilities in that it can not only credit the meter but also provide limited tariff and credit details if the infrastructure is configured correctly. This two way functionality is more developed in the *Telexus* key meter which provides more flexible two-way functionality. Finally, there is the smart card that provides two way functionality and is overseen by the Smart Card Electricity Metering Association (SCEMA). The *Quantum* gas prepayment system uses smart card technology (see section 8.3.4).

Vending agents for prepayment meters include the utilities in-house shops, independent agents, such as corner shops or 24-hour petrol stations or national chain outlets such as Post Office Counters, Paypoint or De la Rue. The vending technologies either use countertop sales or electronic points of sale for some of the more advanced smartcards (Southgate, 1998).

Table 17: Prepayment Meter Populations in the UK

Type	Electricity	Gas
Key (*Telexus*)	1,533,200 150,000	-
Token	1,760,650	500,000
Smartcard	267,000	700,000
Coin	A Few	-
Total	3,560,840	1,200,000

Source: Southgate (1998)

12.4.6 Power Line Carrier (PLC)

The attraction of power line carrier technology is that it covers every electricity supply site. By using power from the electricity supply and modulation data, very high communication rates back to a substation can be achieved. Deployments of this technology have increased significantly in the USA in the last few years, and it remains to be seen if this will be repeated in the UK. Much development has been done into achieving low error rates allowing 'real-time' and two-way data transmission speeds over 20,000 bits per second. PLC systems are favoured by many electricity utilities, as they effectively already own the 'network'. This of course illustrates also the major drawback of power line carrier technology in that it is not attractive to water or gas companies who do not have a connection to the electricity network (*British Standards Institute*, 1998).

Vignette VI

The fact the PLC is part of the electricity network raises a number of issues not least about incremental versus radical change. A lot of what is happening in the competitive world is incremental. Competing utility suppliers are not going to win customers all in one electricity grid supply point. They are going to acquire them in ones and twos. So the Regional Electricity Companies are in a strong position. They control every LV mains into every household in the UK. Probably the greatest exponent of this strategy is the consortium formed between NORWEB and Nortel, the Canadian telecommunications company. They plan to provide data to the Internet market (and ultimately voice telephony) at the local level:

"The magic of this technology is that it essentially brings the Internet into the home, and on a flat tariff basis. It will be just the start of further wireless, Internet and multimedia developments."

(Source: Interviewee: John Newbury, Open University)

The general feeling in the industry is suspicious towards the Norweb/Nortel consortium:

"We will have to see. There are many people very circumspect about the claims that are being made about that system."

(Source: Interviewee: John Newbury, Open University)

12.4.7 Cable TV (CATV) and Satellite

While cable appears to offer an ideal combination of very high data rates and access to new services, it suffers from the limitation of not having universal coverage like telephone systems using the PSTN or PLC. Conventional dial-inbound systems can be deployed on CATV telephone connections but the use of the broad bandwidth fibre optic connection appears to be unjustifiable at the moment (Woods, 1998).

Switching the argument on its head and taking it from the cable companies' point of view, many feel that if they wish to obtain the widest coverage possible then a collaboration with a utility may prove fruitful. Hyder's joint venture with Cable Tel may be a case in point. Metering could be regarded as a value added service to home entertainment. Since one of the major restrictions to the development of smart meters is a costs issues the only way in which a two-way communication could develop would be through such added value services. Shared line technology such as this, offer significant benefits over many other types of network. The fact that the service is shared by other utilities means that costs for each of the individual services can be reduced. In addition, if more than one utility meter can be contacted from a device sharing one line, thus costs would be reduced even further. Sharing a line allows equipment to be installed in a very wide variety of situations and once configured allows it to operate autonomously. So there are both cost and practical benefits of this technology and it would not be difficult to see the costs reduce still further as competition increases in the telecommunications sector. There are a number of programmes that are looking into this concept of shared services. Home and Building Electronic Systems (HEBS) is there to develop the communications associated for data and information systems into the home. DYCE and ETHOS are projects where remote signals are being sent out to control load. This has led to EHS version 1.3, which is the latest European standard of compliance that instructs appliances such as washing machines, cookers etc. Systems are being tested on signals using telephone, cable radio and power line carrier technology.

Vignette VII

"The application of electronics and communications to the equipment located at the customer/utility interface has dramatically increased the functionality of

meters. The humble single function utility meter is undergoing a metamorphosis to a customer electronic terminal. Added value services are not restricted to any one party. Innovative suppliers will also provide the customer directly or indirectly with services such as multimedia, automated home management and entertainment technologies. As the 'meter' metamorphoses into a 'customer terminal', communication is becoming the pivotal technology in facilitating the information flow."

(Source: Interviewee: Stephen Holmes, EA Technology)

A key requirement when developing different technologies is integration. All of these systems in use must operate together and provide common standards and protocols.

12.4.8 Standards and Protocols

Standards in metering and communications are defined at three levels. First, at the international level there is the International Standards Organisation (ISO) which is the world's governing body. Within the ISO there are then subcommittees dedicated to particular utilities. The International Electrotechnical Commission, for instance, is the subcommittee dedicated to electricity metering and communications. On a second level there is the European governing bodies called CEN for fluid flow metering (including gas and water) and CENELEC for electricity metering. Finally the are the UK bodies such as the British Standards Institute (BSI) and the Codes of Practice which define the metering required for the Electricity Pool and the Network Code.

There are also standards being developed within the UK. Under BSI there is the committee called PEL 205A which is low voltage mains signalling. There is also PEL 894, which is metering communications for gas and water. Both of these committees along with all other EU countries, feed into the European commission (CEN and CENELEC). So the GSM digital telephone standard was 'hammered out' in this way through a series of committees in Europe. In parallel this there is IEC which has associated communications committees at the United Nations level (*British Standards*

Institute, 1998).

These standards then require to interface with technology software being developed in the competitive market. This is done by agreeing at National, European or International level a piece of software or hardware which has been developed by a manufacturer. For example, within Europe the DLMS (Distribution Line Messaging System) is being developed. Within this system there are protocols that need to be developed and this is generally done at the National level. The *flag* protocol, which was developed by the meter manufacturers Ferranti and Landis & Gyr is a recognised international standard (*British Standards Institute*, 1998).

In reality a number of protocol standards have developed at international level for meter communications in Europe it is DLMS and the US equivalent is *Tuker Tape*. There are also National sub-standards and protocols which are vying with each other such as *Flag* (UK), *Eurodis* (France), *Mbus* (Germany). Each of these standards do much the same thing with some form of variation. Below this are the UK standards that are needed to comply with the Electricity Pool or the Network Code. In the case of the Pool this is Code of Practice metering (see section 6.3.2) (*British Standards Institute*, 1998).

12.4.9 Information Management

Just as Electronic Point of Sale (EPOS) terminals provide supermarket management with valuable information on customers' tastes, the meter can supply information to public utilities. With the advance of information technology, customer data is becoming one of the most powerful tools at a utility's disposal. As the utilities market continues to evolve, detailed knowledge about the utility's customer is increasing. This has seen the conversion of old customer accounting systems, purely designed for customer billing, into a marketing database.

Vignette VIII

This database management cannot be seen as a core function to supplying energy and water:

Data management in the future will be carried out by organisations who will trade the readings as a commodity rather than provide a service to the utility as it is now. The reason for this is that the value of the data as a management tool outweighs the price of a unit of utility service. Rather than use sub-contractors (or out-sourcing firms) for meter-reading, specialised firms in the future will sell the meter readings to the utilities just as they will sell it to other firms or any other customer. So these firms will be related to the utilities in pure commercial ties (rather than being part of the industry) and a new statutory ethical framework will be required to cover area which the Data Protection Act (1984) could not have foreseen.

(Source: Interviewee: Amatsia Kashti, Olive Domestic Metering Ltd)

The Data Protection Act (1984) does not concern itself with the data owner but the data user. The data user is defined as follows:

"A person who holds data if: the data form part of a collection of data; and that person controls the contents and use of that data; and the data are in a processable form."

(Source: Interviewee: Philip Jones, Data Protection Registrar)

Therefore none owns the data but the data user determines what use/disclosure of metering data occurs, unless there is another overriding legal obligation. In addition, such information contained in personal data should be obtained and processed fairly and lawfully.

This legislation still leaves a lot of room for abuse, and time will tell whether information obtained from utilities company databases will be used for other purposes than billing customers.

One other important area of data management in the UK is data transfer, when customers change supplier. Here the Network Code for gas (see section 8.2.5) and Pooling and Settlement Agreement, as well as the Initial Settlement and Reconciliation Agreement for electricity allow this to take place (see sections 6.3.2 and 6.3.3). These documents ensure that there are effective procedures in place for taking opening and closing meter readings, when customers are switching supplier. They also manage the compatibility of systems for transferring data in a competitive market, such as data standardisation; and the best medium for rapid and efficient data transfer.

12.5 SUMMARY

The application of electronics and communications to the equipment located at the customer/utility interface has dramatically increased its functionality. This major advance has resulted in the humble, single-function electricity, gas or water meter, based only on metrology undergoing a metamorphosis to an electronic customer terminal. This new functionality has not yet been fully exploited. It is judged that when genuine competition is effective, then a rapid exploitation of the new functionality will take place and the word 'meter' may be dropped when referring to this new equipment.

"When historians of the future look back to this era," says John Roth, President and Chief Executive of Nortel, "they'll see that the communications revolution was signalled by a shift from the voice dominated global networks to networks dominated by data. For more than a generation, data traffic has been growing ten times faster than voice - more than 30 per cent per year, versus 3 per cent for voice. The volume of data traffic now exceeds voice traffic, and data will constitute nearly 80 per cent of all network traffic by 2000." (Woodford, 1998)

There are three big waves: the growth of Internet protocol, the growth of broad band widths for video on demand and there is the shift in the present utility infrastructure where gas, water and telecommunications can be traded like financial products. Metering information is just one telecommunications product that can be traded along with television, home banking etc.

There is also a cautionary feeling that for the last fifteen years intelligent metering and the intelligent home have always been five years in the future. There is a basic cost element in the market that has yet to be overcome. Also standards have not been put in place correctly, resulting in too many competing systems. The real snag is that there are a whole number of things going into the home - security, utilities, energy management but not one individual system pays for the gateway.

CHAPTER 13

CASE STUDY No.8:

TELECOMMUNICATIONS IN FRANCE

13.1 INTRODUCTION

France is the second largest market for telecommunications in Europe, after that of Germany. Unlike the energy utilities, which remain nationalised, the global impact of telecommunications liberalisation is just beginning to take effect in France.

France Télécom (FT), the monopoly supplier, is well respected by its users. In several surveys its customers appear to be the most satisfied in Europe (Woods, 1996), although whether that is an accurate refection of the true situation, or one that is coloured by a conservative national attitude, is arguable. Until July 1990, the company was part of France's Ministry of Posts and Telecommunications; for a number of years it operated as an 'independent' but still State-owned monopoly, a move that has given it considerable financial autonomy. In 1997 the French Government sold off a minority of its shareholding, and on January 1st 1998 the French telecommunications network was opened up to competition.

The strategy of France Télécom, which is France's eighth-biggest company, has adapted in recent years to meet the challenges of Europe's slowly liberalising telecoms market. It has entered into joint ventures, with Germany's Deutsche Bundespost Telekom, and Sprint of the USA to provide global networked telecoms services for multi-national companies. France Télécom's ambition to become a major player in the global market for networked voice, data and video transmission has also led to ventures with US West and Ameritech (USA), Britain's Energis, Mexico's Telmex and others.

The company is also actively pursuing links with various European computer-services firms, and has a 19.9 per cent stake in Thomson, the French consumer-electronics group.

This case study will consider the changes that have occurred in France's telecoms infrastructure over the past twenty years. It will outline the changing role of France Télécom, as it tries to become a major player in the global telecommunications market, and how it is reacting to competition within France. The digitisation of the French network, and metering the increasing amount of data telephony will then be considered. The chapter will conclude with an examination of the communications media used in energy and water metering in France.

13.2 THE INFRASTRUCTURE

13.2.1 The Fixed Network

The European Union has been the prime mover in the tentative moves to deregulation of the fixed telephony network in France (Voge, 1984: pp.248-251 & Vedel, 1997). The combination of Directorates General (DG) IV (competition) and XIII (telecommunications and advanced technologies) has for several years sponsored a series of studies and reports on the benefits of liberalisation. This view was well spelled out by the Commission in November 1994 when it stated :

"The competitiveness of European industry as a whole relies on the availability of advanced business and communications services matching, in terms of (their) quality and price, those of their competitors in more liberal economics, such as the US and Japan." (Woods, 1996)

This policy has allowed the Commission to push through many of its directives under

Article 90 of the Treaty of Rome (free trade within the Union). Nevertheless as far as regulation is concerned this is an area where the principle of subsidiarity is likely to be brought into force. A likely compromise is that the European Commission (EC) will formulate the basic principles, leaving their administration to the member States. The EC started the process of telecommunications industry liberalisation as long ago as 1984, with much of the debate concentrated on network harmonisation and liberalisation of services. Following a wide-ranging debate, a resolution was adopted in June 1993 to liberalise the provision of voice services by the beginning of 1998. Other directives have been made in the liberalisation of the mobile, cable and satellite communications markets. In addition to competition, policy directives have also been passed on users' rights (Woods, 1996 & Vedel, 1997).

Vignette I

Although many people see the moves to deregulate the French telecommunications industry as a political issue, a techno-economic argument has also been advocated.

A comparison has been made between the telecommunication industry in the nineteen-nineties and the airline industry in the nineteen-eighties. In the eighties, the fortunes of the French national airline, Air France began to falter. Some of the blame for the demise was placed on the deregulation of the airline industry in other countries:

"If a passenger wished to fly from France to the USA rather than taking a direct flight using Air France, the passenger would take a short connecting flight to the UK and then get a cheap charter flight to the USA. The same principle applies in telecommunications. If someone in France was wanting to phone or send a message to the USA, they could bypass France Télécom's international service by connecting to a competitor who could do it cheaper somewhere else within the EU."

(Source: Interviewee: Nigel Orchard, Pilot Systems)

Whatever the reasons are, this pressure towards deregulation has necessitated a major shift in French Government policy towards commercial activities. France has for long been a country in which Government takes a strong interest in business, known as *dirigisme* (Szarka, 1992). Not only have many of the 'commanding heights of the economy' long been under State control, a situation that has also received the approval of the Conservative Governments, but several of them have been used as national commercial agents of the Government. France Télécom has been one of the leading instruments used by the Government in this manner.

The company's position was once likened by some unkind commentators as being rather like a "State owned bank, that also happens to run the national telecommunications service" (Woods, 1996). The most notable of its shareholdings has been in Groupe Bull, flag ship of the French computer industry, and itself largely a creature of Government. It was founded during the late nineteen-seventies from a series of smaller French companies, with the later addition of Honeywell's computer division. Indeed France Télécom still holds a 14.34 per cent share in Groupe Bull (in early September 1995), following a major privatisation process.

The French Government decided that France Télécom should be gradually privatised, in September 1993. The company is one of twenty-nine State-owned organisations that were selected by the new Conservative Government to be sold over a period of time, to the private sector. This was done partly for reasons of political belief, although a strong secondary motive was that the money was needed to offset a high budgetary deficit.

This overall process has not run at all smoothly. In 1994, seventy-five per cent of France Télécom's workforce joined a token one day strike against the prospect of the company being turned into a private operation. The personnel problem at France Télécom is that more than ninety per cent of the workforce enjoys civil service status. This makes it extremely difficult to terminate their employment. Furthermore the staff have very generous pension arrangements which their contributory payments do not fully fund, while in many cases they receive automatic annual pay increments that are awarded irrespective of their achievements. Indeed until relatively recently, many employees won automatic promotion on the basis, not of their competence or qualifications, but purely by their seniority. Following the strike, the chairman of FT was summarily removed before the end of his term. His replacement however, lasted little more than a week, apparently due to a major disagreement over the timing of the privatisation. In both cases the reason was the same - the desire of Government to avoid upsetting the France Télécom work force, which is fearful about being put into the private business sector (Woods, 1996).

Vignette II

Although turning the company into a State owned public corporation does not necessarily affect any of these characteristics, there has been considerable opposition to these plans:

"The unions fear that, as the first step towards eventual privatisation, this process will in time lead to the severe erosion of their privileges and rights."

(Source: Interviewee: Christian Licoppe, France Télécom)

Much of France Télécom middle management is also known to be bitterly opposed to privatisation, and the trade unions went on strike in May 1995 against such a move, following an earlier strike, in 1994. Employees have seen from earlier occasions (such as the disputes between Air France and the Government in 1994 and the lorry drivers and the Government in 1997) that adamant opposition is profitable. Previous experience is that the Government will almost certainly temporise and then buy their agreement, even if in the long run it might not be deflected from its eventual aim.

The French administration appointed by Jacques Chirac, who was elected President in

May 1995, contained a larger number of ministerial portfolios than before. The objective was to give ministers tighter spheres of responsibility, and as a result be able to reduce their reliance upon experts and - by implication - pressure groups within and outwith Government. Consequently a new Ministry of Information Technology and Post was formed, split off from the former Ministry of Industry, Post and Telecommunications. This has control of new application areas such as multimedia, and one important strength is that it gathers together responsibility for the whole information processing and communications sectors, irrespective of the technologies upon which they are based. Some grey areas although still remain. It is not known for example, which ministry will oversee Groupe Bull, in which the Government still has a majority holding if one includes the stake owned by France Télécom; or how the direction of the creeping privatisation of France Télécom will be handled. Indeed in this latter case the involvement of two ministries must be seen as a backward step. Despite widespread doubt, Lionel Jospin's Socialist Government, which was elected in June 1997 sold (as planned by the previous Gaullist Government) a minority of a shareholding in France Télécom as scheduled. The partial privatisation of its national telecommunications supplier by a Socialist Government seems to be the ultimate *coup de grâce* for the philosophy of deregulation. Nonetheless, French deregulation still has a unique Gallic flavour:

Vignette III

Despite the French Government's reticence to European telecommunications liberalisation, it is yet, ironically, the country that is near the forefront of second-tier telecommunications liberalisers just behind the UK and Sweden:

"The explanation for this really lies in the fact that the country's rulers are nothing if not pragmatic in their attitudes, and once it is appreciated that a particular course of action is likely to be beneficial, then existing theory to the contrary is likely to be jettisoned."

(Source: Interviewee: Nigel Orchard, Pilot Systems)

In France, what are still rather early steps are being taken to build a number of secondary companies to compete with France Télécom in the role of alternative telecommunications operators. Nevertheless, French owned companies continue to be strongly favoured in any competitive bids or awards for licences.

Most prominent of these is Compagnie Générale des Eaux (CGE), which is a company more associated with water distribution, but in 1995 it established a key alliance in telecommunications with RWE in Germany. The company has a 20 per cent stake in Canal Plus, a French pay television channel, and through the British holding company, General Mobile Communications Ltd, has acquired Talkland, a UK radio telephone services distributor. It has also 85 per cent stake in Compagnie Générale de Vidéocommunication, a cable television company. CGE has recently made a move into the fixed telecommunications arena, purchasing a stake in French Railways' (SNCF) communications network. Also CGE has created CEGETEL, its new telecommunications subsidiary, to achieve its objective of becoming the second full-service operator in the French telecoms market when it opened on January 1st 1998. CGE are also active in international telecommunications through their subsidiary CEGETEL, whose partners include British Telecom, who offer support to a fixed link network. Suez-Lyonnaise des Eaux (SLE), which is also in the water distribution business, but is much more a general conglomerate, is also building a network of cable TV licences, rather along the lines of CGE under the name Lyonnaise Cable. A third independent privately owned contender is Groupe Bouygues, which is also a conglomerate, although it is strongest in the property and construction business. Groupe Bouygues and Suez-Lyonnaise des Eaux, had held exploratory talks over a joint venture in Telecoms which eventually broke down (Whitehead, 1997b). One of the problems was that Bouygues, through its control of the water company CISE-SAUR, is one of Lyonnaise's main rivals in the water industry, although the two companies are already working together in TPS, a digital television venture. Instead Bouygues eventually formalised an alliance with Télécom Italia and Germany's Veba (*Utility Europe*, 1998). Bouygues had been looking for a communications infrastructure partner since a rival bid from Compagnie Générale des Eaux beat its bid for a stake in SNCF's communications network. But all the companies stress that they are considering a number of alternatives to achieve their telecommunications goals.

One of these alternatives is undoubtedly Electricité de France (EdF). The French Government is known to be pressurising EdF to enter the telecommunications fray. It makes sense for EdF to move into telecoms since it already has around a thousand kilometres of telecommunications network infrastructure that it can exploit. A law passed in July 1997 grants EdF the right to offer public telephony services along with SNCF, motorways and the Parisian transport company RATP. Although EdF's network is small in comparison with SNCF which has 8,000km, it could be extended to 10,000km of fibre optic cable with an investment of £235 million (Whitehead, 1997a).

13.2.2 The Radio Environment

Although France Télécom's fixed telephony monopoly has remained, until recently, more or less sacrosanct, the mobile cellular communications network was opened up relatively early. France was one of the very few countries outside the Nordic countries and the UK to licence a competitive analogue network operator. Société Française de Radiotéléphone (SFR) who is owned by Compagnie Générale des Eaux, was licensed to compete with the national carrier France Télécom. Unfortunately both companies then established what came very close to being a *de facto* agreement that kept tariffs high, with the result that France has lower mobile cellular subscriber market penetration than any other industrialised country in Europe. In a further move, the Government has since licensed a third competitor. Groupe Bouygues won the award to operate a DCS-1800 digital-based licensed technology personal communications network, and this went operational in early 1996. Groupe Bouygues planed to increase cellular coverage from 28 per cent to 50 per cent by 1998, with 300,000 subscribers against 125,000 in 1996 (Woods, 1996).

13.2.3 The Telecommunications Suppliers and Joint Ventures

France Télécom has also started to dismantle its historically near-watertight coterie of preferred suppliers. Admittedly it remains difficult for any non French supplier to gain a significant presence in the country. Ericsson and Nortel (Northern Telecom) both found the best approach was in close co-operation with Matra Communication, France Télécom's second largest equipment supplier after Alcatel. Alcatel remains by far the most persuasive influence on the hardware sector of the telecommunications market in France but is beginning to come under strain from competitors. Indeed the company is the largest telecommunications equipment manufacturer in the world (Szarka, 1992).

In general, French industry is weak in the information and communications technology sector. In other high-technology areas such as the pharmaceutical industry and electrical engineering, French imports and exports are near equilibrium, but in information technology, the trade deficit is enormous. The deficit was 15 billion francs in 1989, with a cumulative deficit for the decade of 60 billion francs (Szarka, 1992: p.96). Despite the international success of French software firms such as Cap-Gemini-Sogeti, who supply software systems to, amongst others, the electricity and gas industry in the UK, no solution is in sight to make good the deficits. The history of the French computer industry is uninspiring, being marked by a series of unsuccessful State interventions punctuated by US take-overs of French firms.

International co-operation has also been a unique feature of French telecommunications liberalisation with the Atlas and Phoenix alliances. Atlas with Deutsche Telekom, and Phoenix with Deutsche Telekom and Sprint of the USA are key alliances that are intended to underpin France Télécom's entire international strategy. The EU (for both plans) and the US authorities (only for Phoenix) have expressed considerable displeasure over the delays in the deregulatory process in France, and agreement to these alliances were only approved after both France Télécom and Deutsche Telekom made several moves in the direction of liberalisation. France Télécom also has a holding company, Cogécom, which controls most of the group's subsidiaries and affiliates. (Woods, 1996).

13.2.4 'Les Grands Projects'

France Télécom, is regarded as being a French 'national champion' in a country where organisations of this type are much respected. In France, Government influence on telecommunications has generally been benign compared to the energy sector. France Télécom has been encouraged to modernise what was until the late seventies a rather antiquated national network. Two large schemes have been at the core of this strategy. A 'telematics' network, called *Télétel* has put a terminal (*Minitel*) into a third of all households (see Berne, 1997 for details), while *Transpac* has been the largest and most successful national packet-switched network. When *Télétel* started in 1982 the service provided access to business database services over the French domestic packet-switching network (*Transpac*). This was significant, not least because the *Transpac* network charged for calls on a basis independent of distance. An electronic directory service for all customers began operations in Rennes, a major provincial centre, in early 1983. The basis of the *Télétel* system was that the terminals (*Minitels*) up until 1993 were distributed free to subscribers, whereas with *Prestel* (a similar service in the UK) customers had to pay for theirs. There seems little doubt that this is among the reasons why the *Télétel* service, unlike *Prestel*, has expanded in a dramatic way. By the end of 1987, almost 3 million *Minitels* had been distributed to subscribers, and the service is extensively used by both residential and business customers for a variety of database and messaging applications (Woods, 1996 and Szarka, 1992).

13.3 TELEPHONY METERING

France Télécom like its UK counterpart British Telecom has been digitising its telecommunications network. Charges, which were once constrained by pulsed metering, have been replaced by Stored Programmed Control (SPC), an operation system which is controlled by computer software (see section 12.3). The development of *Télétel* and *Transpac* has highlighted the difference between metering telecommunications in the digital telematic environment.

Vignette IV

There are important differences between voice and non-voice traffic. Most voice calls last a few minutes or more. Some non-voice transactions last only tens of seconds. At the same time the speed of transmission for non-voice traffic can be much faster:

"Tariffs for non-voice services should be based on the amount of transmitted information measured as the product of time and transmission rate (bit rate), with no allowance for distance. France Télécom's packet tariffs reflect similar principles."

(Source: Interviewee: Christian Licoppe, France Télécom)

Another point arises directly from the nature of the hardware. In a processor controlled digital exchange, a large part of the equipment is required only while the call is being set up. This is the part concerned with receiving information from the customer about the destination of the call processing it, and using it to set the call up. Once this has been done, this part of the equipment can be released to set up other calls. Only the part of the exchange concerned with maintaining the conversation path stays in use throughout the call. In traditional charging, no distinction is made between the two parts. But short calls occupy the setting-up equipment for just as long a time as long calls:

"In this case, theory of equity would levy a similar charge for the setting-up

process on all calls and differential charges for the transportation path according to duration."

(Source: Interviewee: Christian Licoppe, France Télécom)

The next consideration involves another difference between voice and non-voice traffic. Virtually all voice communications must of their nature be two-way throughout the call. A good deal of non-voice traffic, on the other hand, is (and possibly more could be) one-way for most of the time. Control signals may have to be exchanged at the start and finish of data call, but on many of them the whole flow is in one direction.

All charging arrangements require close study related to circumstances of individual countries and their networks. In practice much of any engineering development involved is likely to be done by suppliers, and patterns of charging are likely to follow international models.

13.4 COMMUNICATIONS IN ENERGY AND WATER METERING

Now that France Télécom is no longer the monopoly supplier of telecommunication services in France, its approach to value added services has changed. The price of the competitive market means that it cannot play a key role in grand infrastructure projects like for *Télétel.* Thus like British Telecom in the UK, France Télécom has very little interest in investing in fixed link communications to energy and water metering unless it pays a commercial return or it is supported by Government subsidy (as is the development of a 'National Grid for Learning').[12] As suggested in Section 12.4,

[12] 'The National Grid for Learning' is the term used for the policy in both France and the UK to connect every education and library facility to the Internet to create an integrated digital network.

metering of energy and water is just another value added network that can be provided through numerous other telecommunications providers. Rather than France Télécom it is Compagnie Générale des Eaux, Suez-Lyonnaise des Eaux and Groupe Bouygues who are already active in energy and water services and are inclined to develop this technology. One obstacle for these multi-utility conglomerates is research and development. Unlike France Télécom, EdF, and GdF, Générale des Eaux, Lyonnaise des Eaux and Bouygues do not have large specialised research and development divisions which have in the past been publicly subsidised. Being private companies, the bottom line of their profit and loss account is the key factor, and not the altruistic development of new technology, which is a major *raison d'être* for the nationalised industries. It is for this reason that EdF may be in the best position to produce a solution to the communications problem in energy and water metering.

Vignette V

Remote communication technology has been used in the French electricity industry for many years. *Ripple Control* is a one-way switching system, which is used throughout many countries in Europe. A signal is sent along the low voltage power line to switch on and off appliances at times of low and high demand. The marginal costed pricing system for French electricity is dependent on this system (see section 7.3.2). Unfortunately this is not a two-way system that can be used for telephony. Electricité de France have considered developing this system into a two-way power line carrier system along with Gaz de France in their shared services division, EdF-GdF Services (see sections 7.1 and 9.1). It seems logical that EdF should develop its mains electrical network to read both electricity and gas metering, a cost that is shared by both companies. GdF however are not so convinced. First the development of power line carrier means that GdF will be dependent on EdF for communications purposes, which is not necessarily of benefit to GdF. The second factor is cost. The cost of developing a power line carrier, which is still not a proven technology, is vastly more expensive than using

a low-power radio network.

(Sources: Interviewees: Paul Bongrain, EdF and Phillippe Vanbleu, EdF-GdF Services)

The population density of France is low compared to that of Germany, the Netherlands and the UK. Yet it has one of the least well-developed radio wave cellular networks in Europe. This can be accounted for by the dominance of France Télécom in the fixed communications market and past restrictions on competition. So because of EdF's monopoly of power line carrier and France Télécom's monopoly (and lack of interest), radio waves are the medium of choice to read energy and water meters in France. The mobile radio companies set up by Compagnie Générale des Eaux and Groupe Bouygues seem best placed to take advantage of this. At the same time, there is a cross utility link with there water and energy subsidiaries resulting in a similar multi-utility phenomenon that is being displayed in the UK. Although metering companies such as Itron and Ramar are aggressively operating in the French market there is an obstacle with government policy particularly over protocols for transmission bandwidth.

Vignette VI

The one major bottleneck to the development of sophisticated metering in the energy and water utilities in France is the lack of an agreement of common communications protocols. This is seen as a distinct business opportunity in countries with a more free market tradition such as the UK and the USA, whereas as a general rule in France, standards and protocols must be agreed on a political level before manufacturers produce them:

"We have to get approval from the ministry before we can carry on with the project of automatic meter reading of energy and water. Every country has regulations for modems just now, so everyone has to ask for an agreement when the device is exported. We hope that in a short time we will have an agreed system by the Ministry of Telecommunications."

(Source: Interviewee: Jean Gasc, SLE)

Entrepreneurial companies such as Itron and Ramar are viewed with some suspicion and they are expected to follow standards that are agreed at Government and Inter-Governmental level. This is a view that is common to all the French utilities interviewed in this study:

"Only one standard will be agreed. It will be agreed at the European technical committee level who define standards in remote systems metering systems (CEN for water and gas, CENELEC for electricity). In fact, it includes all communications that have to be supplied in the home. You see the problem is that if every manufacturer is looking to create their own proprietary standard this causes immense confusion. So we are waiting for a new law from Brussels before remote communication can be installed in energy and water meters in France."

(Source: Interviewee: Jean Gasc, SLE)

13.5 SUMMARY

The liberalisation of the French telecommunications sector has two themes. First, to expand the French national telecom supplier France Télécom internationally by making strategic alliances such as Deutsche Telekom (Germany), Sprint (USA) and Energis (UK). This is similar to the trend that is happening in the airline industry where KLM (the Netherlands) has ties with North West Airlines (USA) and Air UK (UK); and British Airways (UK) has ties with American Airlines (USA) and Qantas (Australia). Second, liberalisation is taking place in the domestic market but with a particularly French bias. Franchises for mobile and cable networks are being sold exclusively to French-owned multi-utilities including Compagnie Générale des Eaux, Suez-Lyonnaise des Eaux and Groupe Bouygues.

With respect to the development of telephony in energy and water metering in France, France Télécom is no longer the only service provider, so it will not invest in telecommunications infrastructure for utility metering as it was able to do for *Télétel*. Indeed Vedel (1997) suggests that this may signal an end to France's high tech

Colbertism. The major competitors to France Télécom are emerging from companies who have experience elsewhere in the utility sector, in particular Electricité de France, SNCF, Générale des Eaux, Lyonnaise des Eaux and Bouygues. Any development of electronic metering and communications is likely to be in a joint venture between these companies, a meter manufacturer and a communications software company. The tendency for French companies to build partnerships would suggest that Schlumberger and Cap-Gemini would be the best placed to take on this role. Before progress on sophisticated metering takes place however, French business is waiting for Governmental approval for the development of metering communications technology. The contrast between this policy and the one in the UK where *de facto* standards are defined by market mechanisms, is striking.

PART III

THE ANALYSIS

CHAPTER 14

THE ROLE OF TECHNOLOGICAL INNOVATION IN REGULATORY DEVELOPMENT

14.1 INTRODUCTION

Chapter 3 of the thesis argued that technical, economic and social as well as many other factors, play a role in regulation. For the purpose of simplification and clarity, three *régimes of régulation* were discussed. Austrian and Monetarist approaches represented the market orientated theoretical frameworks. The socio-political was discussed within the notion of *The Paris or French School*. Meanwhile the role of technical innovation and regulation was introduced through the principle of the *Techno-Economic Paradigm*. This latter mode of regulation was used to introduce the methods that are being adopted in this study to analyse the effects of technological innovation on the regulation of utility industries. In reality it is wrong to bound regulation into these headings since the process of regulation involves the interweaving of these, and additional factors. Moreover these factors may be subdivided so that many of the social equality issues could be divided into, for instance, race, gender, age, or class discrimination. This notion of the inability we have in bounding concepts and the necessity to take pragmatic approaches to theory, is a constant theme of this work. For the present, the approach adopted in this chapter is to examine how technical factors affect the other components of regulation. In effect, to examine the role that innovation in information technology has played in the changes described in the case studies in Part II.

Section 4.4.6 discussed how Beesley and Littlechild (1992) argued that some functions, such as electricity and gas supply, could no longer be considered as 'natural monopolies'. Further it was postulated that the reason for this is that information technology has shifted the *Techno-Economic Paradigm.* A clue to the role that information technology has played in the deregulation of public utilities can be found in Freeman & Perez's (1988: pp.45-47) examination of the taxonomies of innovations. In Freeman & Perez's analysis there is a distinction between (i) *incremental innovation*; (ii) *radical innovation*; (iii) *new technology systems*; and (iv) changes in the *Techno-Economic Paradigm.* This theme will be used in an attempt to interpret the changes in the regulation in the public utilities over the past twenty years in the UK and France. In order to make the theoretical base more appropriate to public utilities the analysis will also consider Saehney's 'highway' heuristic (see section 5.3.1) which presents the stages of infrastructure development of the public telephone network. Although Saehney's study is restricted to transport utilities, it will be used as a starting point for a broader model for infrastructure development in both energy and transport utilities.

The structure of this chapter combines the cases studies examined in Part II together with the literature reviewed in Part I to compare and contrast the influence that information technology and regulation has had in the development of the telecommunications, electricity, gas and water industries in the UK and France. In the conclusion there is discussion about whether technological explanations alone are enough to explain the revolution in public utility management and if the *Techno-Economic Paradigm* is an effective framework to analyse these changes.

14.2 TELECOMMUNICATIONS

Both France and the UK are now in the process of restructuring their telecommunications network. Britain began in 1983 with the Telecommunications Act while France started some ten years later in 1993. Although this trend towards both privatisation and deregulation has political motives founded in creating a single European market, this does not answer the question: why has deregulation happened in the telecommunications industry in France while it has not yet occurred in other public utilities?

Saehney (1992), in his study of the stages of infrastructure development of the public telephone network, refers to telecommunications as the 'highway' of the information age. Significantly he also highlights the development of digital networking and fibre optic transmission media to underscore its social and economic importance. The analogy of a relatively simple metaphor the 'highway' is used as a heuristic device for model construction. It is argued that the experience with transportation (railways, motorways, and airways) technologies can be used to develop an abstract model for understanding the growth pattern for emerging telecommunications technologies. In section 13.2.1 the restructuring of the global telecommunications network was compared to the restructuring of airline travel. Just as airlines have developed partnerships or even have amalgamated (e.g. KLM, North West and Air UK), over the last few years national telecommunications networks are making strategic alliances (e.g. France Télécom, Deutsche Telekom, Sprint and Energis), in the ever-increasing international telecommunications market.

In the case of telecommunications, the interconnections or the 'system of relationships' between elements are more important than the constant elements themselves. This 'system of relationships' is greatly influenced by social, economic and cultural factors. For example, the increase of international data rather than voice traffic, has a social and economic impact. This socio-technical system has given birth on both sides of the English Channel, to Government initiatives that aim to put an Internet connection in every school and library. This grand project or 'National Grid for Learning', as it is dubbed, is a relatively new concept (in modern times at least) in the UK, but is well established in France. *Télétel* is such a grand system and was developed in the nineteen-eighties with joint industry and business co-operation with the aim to enhance the telecommunications infrastructure. The implication of this type of investment is that the actual placement of the network on the geographical space is an artefact of social design as well as engineering and cost considerations. In other words, such concepts as teleworking can just as easily be achieved in a distributed environment such as the home as in a centralised office environment. This means that the network structures of the infrastructure technologies grow in the socio-cultural milieu of the larger society. Different societies are likely to influence the development of the infrastructure technologies in different ways. Some may focus on fixed line networks while others may use radio communication. However, within the socio-economic system, the organising principles for the 'system of relationships' even if different infrastructure technologies are used are likely to be the same. Thus common ground rules can be developed which can map the technology and infrastructure change in formal theoretical frameworks.[13] Issues like the development of uniform operating procedures and the adoption of standardised technology then become important on a European and world-wide scale.

The *Systems Theory* framework used by Thomas Hughes in *Networks of Power* (1983) described the formation of new electricity networks up to 1930. This differs from the systems being described in telecommunications today where we are witnessing a shift from one mature infrastructure to another. In other words, there does seem to be a paradigm shift in both the way the industry is structured and how people are using the technology. But within this shift in the *régime of régulation* differences still persist. In France, priorities for telecommunications franchises have been overtly given to French owned companies. EdF and SNCF with their infrastructure of cables and lines have been encouraged to enter the telecommunications market. Moreover the three French-based multi-utilities, Compagnie Générale des Eaux, Suez-Lyonnaise des Eaux, and Groupe Bouygues have been very active in the developing telecommunications market. In the UK, less emphasis is placed on the national identity and competing companies, which has meant that companies from the USA, Germany and France play increasing

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[13] Such as Sociotechnical Constituencies, Techno-Economic Networks and Evolutionary Theory, see chapters 15 and 16

roles. So the French model for privatisation and deregulation has moved in line with that of the UK. Also, the UK has adopted a more French approach to the infrastructure development since the election of the Labour Government in May 1989. The converging of telecommunications infrastructure polices signifies a harmonisation of telecommunications infrastructures within the EU. Nonetheless it is difficult to argue that EU harmonisation legislation alone has prompted this change since this can be also a global phenomenon. The conclusion is therefore that the technology development has a major role in this change, and information technology is indeed changing the *régime of régulation* in a similar way as described by the *Techno-Economic Paradigm* in the telecommunications sector.

14.3 ELECTRICITY

In many respects, prior to 1989 the management of the electricity infrastructure in France and the UK were similar. Early development prior to 1945 was through a mixture of private and municipal electricity companies. Consumption was concentrated in areas of urban conurbation. Generation meanwhile was by coal-fired power stations associated with these urban networks. With nationalisation and rural electrification policies, infrastructure characteristics began to diverge in both countries.

The first reason for this was the differing geopolitical stances of France and the UK. France, having a much lower density of population than the United Kingdom has therefore a larger distribution and transmission infrastructure. France is also much more poorly endowed with indigenous energy resources, while the UK is self reliant with an impressive mix of energy including oil, gas and coal. Both were also in the forefront of the development of the nuclear power industry. However, it is France who has probably more than any country in the world staked its future in this technology. This form of energy accounts for some 80 per cent of French power production compared to 20 per cent in the UK. The reasons for this division in policies are clear. France, fearing the reliance on imported oil, gas and coal made a conscious decision to invest in nuclear power and today is not only self sufficient in electricity, but is a major exporter to the rest of Europe.

Since 1945 the mode of governance in both countries was publicly owned and operated. This meant that economic, social and technical considerations could be accounted for in an integrated fashion. This was vital to the development of the nuclear and hydro-electric industries as well as to rural electrification in each country. At the same time, demand for electricity was steadily increasing as a result of economic growth. The development of the electricity infrastructure had a number of unique features. Electricity has many features of a natural monopoly. Generation was seen to be dependent on strategically important fuels and could not be left to the market, viz. the French nuclear policy. In transmission and distribution it would be too costly to install two or more competing electricity supplies into a single consumer's premises. Also since there was no market in generation and transportation, it was difficult to imagine a market for supply. As a result, infrastructure development was done in an integrated way. This meant that the State-owned utilities could develop a pricing mechanism such that an area of the network that was more expensive to supply, such as rural areas, could be subsided by areas where it was less costly to supply. In addition, the nature of electricity is such that it is very difficult and expensive to store once it has been generated and this has meant that as far as possible supply should match consumption. This led to a form of pricing based on marginal cost, which relied on a vertically integrated network infrastructure.

In summary, prior to 1989 the electricity infrastructure in both the UK and France was built on the post-war geopolitical canvas in which the nation State aspired to provide all its citizens with a safe and secure electricity supply at equal price. This meant that each State was responsible for ensuring that it had enough fuel to power its country's economy and maintain its social structure.

In the eighties the changing geopolitical, economic and technical environment meant that integrated network framework either had to adapt or be restructured. Two major factors have been responsible for this. First, the role of the French and the UK Nation-State has been subsumed in a greater entity, namely the European Union. One of the effects of this is to tear open many of the trade barriers between these countries and the rest of Europe. In the electricity industry this has come as a shock to France. France has expended considerable investment in nuclear power, tailoring it to the needs of France rather than the European Union. Thus the prospect of a free European power market is not relished by the French. Second and possibly even more important is the development of information technology. Modern communications and data processing facilities have enhanced the prospect of a competitive market. The England and Wales Pooling and Settlement System is an example of this. This has in turn, delivered the prospect of competition in electricity supply. The UK has been able to implement these policies not only because of political will but also, unlike France because it has a plentiful supply of fuels and did not commit itself fully to nuclear power in the nineteen-seventies. The prospect of introducing such a system in France is clear. The monopoly of EdF in France would be shattered, the nuclear programme would be threatened and the position of the French State in Europe would be compromised.

Thus the role of technology, and in particular information technology, in the process, is being acted out in combination with these other constraints (geopolitical, social and economic). Nonetheless, it is allowing a combination of interrelated product, process, technical, organisational and managerial innovations to take place. These changes have taken distinctly different forms due to the differing socio-political contexts in the UK and France. In the UK, information technology has facilitated the development of competitive trading, while in France the same technology has been used to make the vertically integrated nationalised structure more efficient (through increasing load factor).

Transactions are now made on a global basis twenty-four hours in a day and at the speed of light through a fibre optic cable. This has not only had considerable influence on the financial services and retail industries but also the energy utilities. The England and Wales Pooling and Settlement System in electricity could be described as change of the *technology system* (Freeman & Perez 1988, pp.46-47). In order to make this change there has been *radical innovations* on how the technology has been used to implement the trading arrangements in electricity. For example, all 'over 100kW' customers require to have a meter that can record demand on a half-hourly basis, and a communications devices which can down-load the information to a settlement system. Also computer systems require to record the smooth transition of customers who wish to change supplier. Below this layer there are further *incremental innovations* that can only be arrived at through iterative trial and error mechanisms operating in the new system. Thus after ten years of operation, the England and Wales Pooling and Settlement System is continually undergoing reviews to consider these *incremental changes*.

In the French system the *Techno-Economic Paradigm* has been approached from a production standpoint. So rather than changing the structure of industry, managerial and operational innovations have been considered in EdF and GdF. In this *régime of régulation*, the changes in the technology system are more concerned with making the methods of production more efficient rather than changing the methods of trading. In electricity and gas the focus is therefore in making the energy supply better match energy demand; and with electricity also the development of 'time-of-use' tariffs using sophisticated metering. *Incremental innovations*, are important here particularly for demand side management. EdF for example has significantly broadened its tariff structures in order to reflect EdF's generating costs. So rather than changing *technology system* by *radical innovations*, *incremental innovations* have been used to make the incumbent system of regulation more robust. For example, since 1981 EdF has broadened its tariff range and now has over twenty different forms of 'time-of-use' pricing. These *incremental innovations* have developed in a format that is closer to 'learning by doing' in a more iterative process than the radical process that has occurred in the UK.

'Real-time' pricing has also been introduced to compensate for uncertainties affecting the electricity market in both the UK and French systems, but by means of two very different mechanisms. In the UK it is by means of a 'spot market', while in France it has been through three 'real-time' tariff options. Thus it would be expected that in future pricing and as a consequence, metering will develop in differing ways to reflect the differing infrastructure systems.

Superficially the telecommunications industry and the electricity industries are similar. They both involve transportation networks carrying electrons (albeit at vastly different voltages and currents). Nevertheless there are significant differences, the major one of which is that the electricity industry not only involves the transportation of power, but also its generation. The fact that every light bulb or every microprocessor has to trace its origin back to a power source is significant, while in telecommunications this is not the case. This issue has led to two very different models for the electricity industry. These two forms of regulation are the *Third Party Access* model and the *Single Buyer Procedure* (see section 7.2.3). Both are essentially incompatible but are made possible by subsidiarity clauses in the European Law. Neither however, should be seen as right or wrong. *Third Party Access* has been made possible by a number of factors including choice of fuel, belief in the rigours of competition, the decline of electricity as a strategic resource and the result of a mature electricity infrastructure. The reason France has not adopted such a model, are twofold. One is its reliance on nuclear power and the other is its suspicion of the unfettered market. The French nuclear commitment is the most significant reason why the French electricity industry will not be fully deregulated in the foreseeable future. However it is the French view of deregulation which is most important. It is not that the French are politically against privatisation and deregulation. The mission of French style regulation is to include policy duties, such as contributing to territorial development and/or national energy independence within the remit of their public utilities.

Thus the heuristic 'highway' device which holds for telecommunications is not appropriate when applied to electricity, due to its inherent generation component. Also, since the separation of the generation and supply components depends on geopolitical circumstances this is difficult to achieve on a global scale since different countries such as France and the UK have different social and geographical characteristics. This has in turn resulted in differing approaches adopted to produce electricity in each of these countries.

14.4 GAS

The aspiration to be independent in energy supply has also hampered the development of the gas industry in France. In the country's policy of developing an independent electricity supply, priority has been placed on electricity generation and consumption rather than gas. As a consequence, Gaz de France appears, until recently, to have been a relatively low profile organisation compared to its United Kingdom counterpart British Gas. In its relationships with EdF, GdF has also been defensive. This again contrasts with the relationships characterising the gas and electricity industries in the United Kingdom where in many areas gas has been the fuel of preference (particularly for heating). The difference is explicable in terms of the profitability of the two industries in the two countries and their access to supplies. British Gas had access to low-cost supplies of natural gas, which as a monopsony buyer it was able to purchase at a low price; this fortunate circumstance allied to the vast volumes of gas available, permitted the industry to penetrate many markets rapidly and easily. In contrast, the resources available to GdF built up more slowly, with the exception of the deposits in Aquitaine. Supplies from Algeria and the Netherlands were at a higher cost and subject to the normal commercial market forces. As a result GdF has had three main preoccupations: its precarious finances; to secure supplies from outside France; and to find markets.

Prior to 1986, British Gas was in a very enviable position. It not only had a monopoly of the transmission, distribution and supply of gas to the United Kingdom, it had a monopsony of purchases of gas from the North Sea. The supply from the North Sea was cheap and plentiful. The investments made in the seventies by the nationalised British gas industry to convert to natural gas and expand the pipeline network, were triumphs of the publicly owned monopoly form of regulation. By contrast, electricity in the UK was suffering from supply problems. Its reliance on coal meant that it suffered from high fuel costs and was subject to trade unions' action, which dogged the British coal industry during the seventies and early eighties. Its nuclear power construction programme, although technically innovative, was expensive and only exacerbated the gap between electricity and gas prices. The story of the nationalised French gas industry during the same period could not be more different to the UK experience. A largely similar regulatory framework produced a network that suffered from under investment and trading restriction with respect to electricity, since it did not conform to France's policy of independence in fuel.

Both the geopolitical and technical circumstances have changed over the past twenty years. The cold war is now over and Trans-European gas networks have been constructed, allowing freer trading of gas. The fear of another energy crisis has receded and the policies of independence in energy, which have been pursued since the oil shocks of the seventies, seem less credible. Competition in the production of natural gas has also been liberalised as a response to both the abundance of resources and relaxation of the political climate. Restrictions such as the British Gas' monopsony, which ran counter to the EU's policies on free trade, have been abolished. Advances in information technology have also created a supply market for gas. The Network Code, for the trading gas and the development of *Third Party Access* has been a *radical innovation* that has ensued, and it has been extremely destructive to BG as a company. It has had to restructure its operations. Transmission and distribution are now seen as monopolies run by a private company under regulation. Production and supply are meanwhile seen as competitive and regulated by the market. Despite this, problems still require to be resolved. A market for gas inevitably means consumers will pay different prices for their gas. This is a consequence of the differing costs of supplying different consumers, and leads to the phenomenon called 'cherry picking' of profitable customers by new entrants into the market. This will undoubtedly prove politically unacceptable if underprivileged members of society are further encumbered by more expensive gas bills than the average. Nonetheless, some form of social levy on gas prices can easily iron out these inadequacies. Indeed customer information and billing systems that are now being developed incorporate spare data fields for such legislation.

While the UK has been introducing this *new technology system*, France has almost stood still with respect to deregulation of its gas industry. It seems logical that industry should evolve to changing technological and social needs, but France's catatonic state towards deregulation in the gas industry can be explained by its indigenous energy policy. It would seem on the face of it that GdF's position could conceivably be improved by deregulation. Most importantly, it would be able to step out of the shadow of its larger electrical sister EdF. Nevertheless it would be wrong to assume that GdF does not continue to benefit from the status quo. GdF can use its dominant position in France as a springboard into the gas industries abroad. Its monopoly position in France makes it a strong force when brokering gas contracts, financing joint ventures, and developing new infrastructure in various parts of the world. This would indeed be seen to be the major loss to the UK deregulation of the gas industry. The power and prestige of BG as an international player has been inhibited by its need to focus on the UK market. Also like EdF it looks at *incremental innovations* to increase its production efficiency such as the development of cryogenic technologies, so that gas can be stored for times of peak demand.

British Gas serves as a good case study to observe the effect that deregulation has on a publicly run utility. Once it is truly reconciled to the changing technological environment and realises that only its pipeline network is still a natural monopoly, progress in the management of a utility can take place. BG should be a salutary lesson to GdF and EdF. The privileges that these companies have, lies in the considerable achievement in network infrastructure gained during the fifties, sixties and seventies. Now that the infrastructure is in place and *Third Party Access* is technically feasible, the only factor inhibiting the introduction of such a system in gas and electricity is France's nuclear programme. Thus the key factors affecting the gas industry in both France and the UK, have been supply side factors.

The story of the gas industries in the UK and France somewhat mirrors that of electricity. The UK has focused on using information technology to develop new competitive trading mechanisms. At the same time, GdF has focused on developing secure supplies of gas. The gas case studies also highlight the importance of indigenous gas resources.

14.5 WATER

When it comes to water, the principle of natural resources come even more sharply into focus. Water resources depend on rainfall, the size of the water catchment area, as well as socio-cultural attitudes towards pricing and metering. Since water bills up until recently have been paid through local taxation and never metered in the UK, it has come to be seen as an almost limitless free resource. Recent droughts in England and Wales, and regulations to increase the quality of waste disposal and the associated price increases, have been a shock to the water consuming public. This need for investment in the water system has been introduced along with privatisation, using the models that were used for the telecommunications and energy utilities in the UK. Significantly however, there is no prospect of competition developing in the water industry. Thus, this privatisation has taken place due to ideological and political reasons, rather than any technological imperative as in the telecommunications and energy industries. This means that the UK Government has shifted the expenditure from the public to the private sector. What is more worrying is that the industry has been left with a form of regulation that lacks both competition and democratic accountability.

Local democratic accountability is the feature that is most cherished by the water industry in France. The system of 'delegated management' where water operation is conducted by private companies is closest to the 'franchised out' system of regulation described in section 4.4.5. It is ironic that the French allow, arguably, the most important public resource to be run by the private sector, considering its aversion to the idea in gas and electricity. One vital ingredient still remains, and that is that the water facilities are still owned by the Local Authorities on behalf of the public. This means that ultimate responsibility for water lies with locally elected mayors. This is undoubtedly an alternative regulatory model to the models of deregulation found in the UK and has stood the test of time, remaining relatively unchanged over the past twenty years.

It is the British who look rather flat footed and ideologically inflexible when it comes to the water industry. Water reform in the UK, rather than being a pioneering exercise has been somewhat of a catching-up exercise on its European neighbours. Although many other of the privatisations were driven by the need for the Government to raise capital, water also required a massive amount of investment to reach EU standards. Since the Government was unwilling to pay for this out of tax rises, it relied on the increased water bills of the private companies to achieve the same thing. Water companies were prime examples of public monopolies being transformed in to private monopolies. In other words privatisation of the UK water industry had little, if anything, to do with technology or competition.

In short, water privatisation in the UK was politically driven. The uncertainty of the method of regulating the water industry is borne out by the fact that it has only been able to be introduced in England and Wales. The water industry in Scotland still is (and is likely to remain) in public hands. Also unlike the changes that have occurred in the telecoms, gas and electricity industries information technology has played a minor role in the regulatory process. On the production side, there has been little attempt in the past to conserve water in the UK. The low penetration of metering in the domestic sector has meant 'time-of-use' pricing, involving sophisticated telecommunications technology has been limited to only a few very large customers. In France, where water is a much more valued resource, metering has been almost universal for a hundred years, and 'time-of-use' pricing is practised, although the impact of information technology has also been minimal. Two reasons account for this. It is seen as a very costly exercise to attach communication devices to water meters and no communication protocols have been granted by the French Government. It is the multi-utilities who hold the key. They have the potential economies of scale and scope to take advantage of innovative information technology. If the benefits of the multi-utility phenomenon are to be realised, innovations in the billing, metering, and demand management functions aimed at reducing costs and improving customer service will be crucial.

14.6 CONCLUSION

This chapter has reviewed the eight case studies of telecommunications, energy and water utilities in France and the UK presented in Part II. It has concluded that no one theoretical framework of regulation or technological innovation is sufficient to describe the activities in the public utility sector. Despite this, some differentiation between theories can be made.

The policies towards telecommunications in both France and the UK have converged and the old national monopolies have made strategic alliances, to compete in the international market. This has also meant that both countries have opened up their domestic market to *Third Party Access*. Nonetheless, the flavour of the deregulation is somewhat different in each country. Thus strong evidence has been presented to conclude that this deregulation has been facilitated by the development of information technology. The Saehney (1992), model of infrastructure development of the public telephone network holds, and similar models referring to the 'highway' heuristic are useful. Indeed, in the telecommunications sector there has been a shift in the *Techno-Economic Paradigm*.

The 'highway' model and the *Techno-Economic Paradigm* are less convincing when considering the electricity and gas industries. Since the supply of energy requires some form of production function, which is absent in telecommunications, the management of the energy utilities is more open to political manipulation. Thus it is concluded that the Saehney (1992), model for infrastructure change does not hold for infrastructure model that intrinsically involves a production function. Within the electricity and gas industries, positions have diverged over the past fifteen years, between the UK and France. The root of the divergence comes from the fact that France is poorly endowed with indigenous energy resources while the UK is well endowed. This led to energy policies that are singularly French (the *Single Buyer Procedure*) and ones that are promoted by the UK (*Third Party Access*), which are almost diametrically opposed. It is also argued that this is not an ideological debate but a pragmatic one. Since the French Nation has invested in a massive amount of effort and resources in developing its nuclear industry, and is almost totally reliant on its supply of gas from external sources, leaves it vulnerable to deregulation. In contrast, the UK's abundance of oil and natural gas gives the ideal opportunity for the development of *Third Party Access*. It is also argued that information technology has been shaped differently in each of these countries in response to their socio-political needs. In France the technology has focused on *incremental innovations* which have involved the development of sophisticated metering and tariffs to make the consumption more reflect the cost of supply. In the UK *radical innovations* have resulted in competitive trading systems such as The England and Wales Pooling and Settlement (electricity) system and the Network Code (gas). This in turn has introduced a *new technology system* into electricity and gas, changing the social fabric of public utilities in the UK.

In contrast to the other case studies that impact of the information technology revolution has so far been minimal in water. *Third Party Access* is not a practical option, and therefore trading mechanisms cannot be developed. With respect to resource management, there are opportunities which to date have not been fully realised. In the UK the low penetration of water metering in domestic premises means that the potential of cost reflective pricing remains unused. In France where metering is universal, the cost of installing sophisticated communications modules is seen as prohibitively expensive. This, together with the fact that communications standards in metering have yet to be agreed, means that the information revolution has yet to arrive in the water industry. Nevertheless the trend towards the creation of multi-utilities is a notable feature in both countries. In theory multiple utilities have the ability to pool the costs of administration (including information technology over a number of utility functions).

Thus it can be concluded that the information and telecommunications industry has played a key role in the regulatory change in public utilities over the past twenty years. Yet the contribution that information technology has made varies between different public utilities. Advances in computing and data processing have had a significant impact in the restructuring of telecommunications, from nationalised public utilities to privately-owned multi-national companies. It is therefore concluded that the 'highway' model can be a useful heuristic device to track this change. However, in the gas and electricity industries models like the *Techno-Economic Paradigm* begin to break down. There has been a change in the technological system within electricity and gas in the UK, with the privatisation of these industries and the introduction of *Third Party Access*. Information technology in this case is used to develop trading systems to introduce competition. France on the other hand, has used the technology to make its production more efficient by the use of integrated resource planning in order to preserve the nationalised and vertically integrated structure. Thus in the energy utilities, information technology has been overtly shaped to achieve two different sociotechnical ends. Meanwhile the impact of information technology in the water industry has been less striking. The *régime of régulation* in France has remained unchanged while the privatisations that have occurred in England and Wales have more to do with political and economic ideologies than technological factors. An attempt is made to map the dynamics of these technological and systems changes using the frameworks of *Sociotechnical Constituencies*, *Techno-Economic Networks* and *Evolutionary Theory* (see sections 5.3.2, 5.3.3 and 5.3.4) in chapters 15 and 16. This will give further insight into the textural changes that are causing technical and regulatory changes in the public utilities of both the UK and France.

CHAPTER 15

METERING TECHNOLOGY IN UK AND FRENCH UTILITIES

15.1 INTRODUCTION

The previous chapter considered the role that information technology played on the development of public utility regulation. It was concluded that although the *Techno-Economic Paradigm* was of significant importance in telecommunications, the role that information technology played in energy (gas and electricity) and water regulation, was more complex. This chapter further explores this relationship by considering the development of metering and telephony in the electricity, gas and water industries. Chapter 4 described the role that metering plays in the regulation of public utilities. The purpose of this chapter is to analyse the development of metering technology in light of the evidence presented in the preceding case studies (chapters 6 to 13). In other words how the infrastructure system (*régime of régulation*) has been embedded on the artefacts (meters). The chapter goes on to analyse this development by using *Sociotechnical Constituencies* and *Evolutionary Theory* (described in chapter 5) and concludes by an appraisal of the suitability of frameworks for describing and explaining metering innovation and makes some recommendations on metering policy.

15.2 THE DEVELOPMENT OF METERING

15.2.1 Increasing Load Factor

The maximisation of Load Factor is one of the most crucial drivers to technological innovation in the electricity and gas industries in France. Each industry however solves the management of this issue in differing ways. Gaz de France has focused in on gas storage techniques such as liquefied natural gas for peak shaving and underground storage for seasonal demand. The role of metering in the French gas industry therefore has progressed little in use from a metrological device used to charge customers. This is not to say that the electronic and ultrasonic meters (see section 9.3.3) are not technological advances but they have been driven by a need for better measurement rather than any system management properties. The role that metering plays in the management of the French electricity infrastructure is considerably more important. France has pioneered the use of 'time-of-use' pricing which has been supported by innovative metering technology. Section 7.3.2 described the numerous tariffs employed by Electricité de France in this policy of system management. Thus the development of metering technology in the French electricity network has been directly used to make the production function (electricity generation) more efficient. Moreover this policy is most effective when it is applied to a vertically integrated monopoly such as EdF. So the role that metering technology has in the French electricity industry is two fold. The direct consequence is to maximise load factor but in doing this it also strengthens EdF's monopoly powers.

15.2.2 Liberalisation of the Energy Market

The UK gas industry prior to 1986 and the UK electricity industry prior to 1990 were vertically integrated (see chapters 6 and 8). 'Time-of-use' pricing and appliance switching were seen as prime movers in increasing efficiency through flattening the load profile. The subsequent unbundling of these industries in the UK has shifted the role of metering technology from maximising load factor to one that has facilitated deregulation. So, the parts of metering technology that help to develop competition have been stimulated by the process. Mandatory Code of Practice 3 & 5 metering, which has incorporated in it a communication medium and half hourly recording, has made 'real-time' pricing possible in the 'over 100kW' market. This is an example of where a regulator imposed a technological solution on an industry. By contrast, technologies that thrived in the integrated environment have not fared so well. 'Time-of-use' pricing, technologies such as teleswitching and the associated communications media have been considerably inhibited. This inhibition of the technology has been intensified by two factors in recent years; the decision to opt for profiling in the 'under 100kW' market, and the opening up of the meter operations and data collection market to competition.

To summarise, the use of profiles for full market liberalisation in 1998, has meant considerable developments in customer information systems but has left metering technology unchanged in domestic premises. Nonetheless, some optimism still remains that when the competitive environment becomes bedded down and more Code of Practice 6 and 7 new meters will be installed (with their added functionality in recording aggregated demand data). For example, an electricity supplier may wish to use 'time-of-use' and even teleswitch technologies, in some form of energy portfolio management project in the future.

15.2.3 Abolishing Rateable Value Charging in Water

In England and Wales the water industry's move away from rateable value charging in the year 2000 (see section 10.3.2) is a tangible sign of a change from treating water supply as a social good to an economic good. This effort to develop a more cost reflective price structure has obvious advantages in producing a more efficient use of water. Conversely there is a social cost. Customers with large families in low rateable value houses are likely to gain least from this system. At present the argument for all domestic customers to be metered has not been won.

In view of the fact that water companies are supplying drinking water it is not surprising that water companies are subject to environmental and quality regulation.

Moreover recently increased domestic consumption combined with recent years of lower than average rainfall and EU directives on water quality, have placed leakage and water conservation as a high priority in certain parts of England and Wales. Universal metering is argued to be a solution to this. This is the ace that the water metering industry holds and this card is played by environmental as well as economic lobbyists. The argument is that it will be more costly and damaging to the environment to build new reservoirs, treatment and sewerage plants than to install meters to control customers' demand. It is these environmental and economic dimensions which mean that the water industry has the greatest scope for technological innovation in metering over the next few years.

Water companies who have already a major programme of new meter installation, are in an ideal position to install additional features and modules to their meters at a marginal cost. Moreover, the uncertainty caused in the energy utilities by metering liberalisation has left water companies relatively unaffected due to their relatively low penetration of domestic metering. Thus it is the needs of the water industry combined with the multi-utilities or horizontal integration of specialised companies dedicated to meter operations and data collection, which may provide a spur to such functions as automatic meter reading.

15.2.4 Prepayment Metering

Prepayment metering is a popular method of paying for utility products in the UK (see sections 6.3.6, 8.3.4, and 10.3.2). The present method of prepayment by a card or key is a primitive form of two-way communication in that a customer has physically to buy a prepayment card before consuming the product. Here there seems to be some form of scope (which at the moment is not clearly articulated) for future automation of this process, using either a fixed link or particularly a radio communications infrastructure. In contrast to the UK, France has very few customers who pay by means of prepayment. Since the utility assets are all publicly owned (in water the assets are municipally owned but the operation is often delegated to private companies), payment is seen more as a social, rather than an economic issue.

15.2.5 Liberalisation of Meter Operations

Sections 6.3.4 and 8.3.5 described the plans afoot to deregulate electricity and gas meter operations in the UK. Meter operations in the electricity industry, which includes meter ownership, meter installation and meter maintenance has been progressively deregulated since 1989. Plans for the liberalisation of meter operation in the UK gas market are a little further behind, but Ofgas has clear intentions to liberalise this market in the not too distant future. The uncertainty caused by the deregulation of meter operations has been a major inhibitor in the development of sophisticated metering and communications technologies. The uncertainty caused by the opening of these markets has caused under-investment and stagnation. This is a clear example of where a lack of regulatory vision is actually inhibiting innovation. The issue centres around the fact that if a company loses its franchise for meter operation it will be left with stranded metering assets. The regulator therefore requires to look very carefully at the issue of meter ownership. Particularly different forms of contracts where the meters may be owned by one party and then leased to the meter operator are required to be considered. Alternatively, the regulator may consider separate regulation for meter ownership, meter installation and meter maintenance in a similar fashion as the rail industry in the UK.

15.2.6 Liberalisation of Data Collection

In addition to the liberalisation of meter operation the electricity and gas regulators have installed or will soon install, competition in the data collection function. The data collection function consists of collecting raw data and giving it to a settlement administrator so that it can then be presented in a format that is usable for the distribution and the supply functions. In the gas industry this function is entirely deregulated and is no longer being carried out by the monopoly distributor of gas in the UK, TransCo. In the 'over 100kW' electricity market this function has been conducted by United Kingdom Data Collection Services (UKDCS), a company owned largely by the 12 English RECs since 1994. In 2000, UKDCS' franchise for data collection in the 'over 100kW' market, comes up for renewal and the data collection for all customers is put on a competitive footing. The prognosis for technological innovation in data collection is a lot more optimistic than for meter operation. There seems to be a number of interested parties who wish to read meters, such as AccuRead and Northern Metering Services. But there are two noticeable features. The companies entering the market tend to be subsidiaries of RECs or joint ventures as in the case with AccuRead (British Gas and Group 4). The other trend is the tendency to use low technology solutions. Companies are finding it cheaper to use pedestrian meter readers rather than electronic media. In the one instance where electronic media is being used, namely UKDCS, in the over 100kW market in electricity, the situation is reversed. This is due to the fact that the technical specifications of half hourly electronic meters and communications were defined before deregulation. It is difficult to imagine anyone with either the financial capital or technical experience challenging their monopoly, unless some form of regulatory intervention is contemplated. Nevertheless joint ventures and strategic alliances, particularly with information technology and cable companies, may overcome barriers to enter into the market once the system has bedded down. Multi-utilities are an obvious example of this trend in the UK. It is also significant that EdF and GdF have always had joint data collection facilities (EdF-GdF Services).

15.2.7 Data Security

Another issue in the area of data collection, which needs close regulatory scrutiny, is data protection (see section 12.4.9). It could be conceived that data collectors will trade with the readings as a commodity in addition to providing a service to the utility, as is the case now. In the UK the general rule of thumb is that customers should agree to information on their utility consumption being used for other purposes such as direct marketing. The increased quantity and accessibility of utility load profiles may contribute to an actual hostility to automatic meter reading amongst domestic customers. It is noteworthy here that metering of telephony which is carried out centrally on telephone exchanges and not at the home, is now a highly automated process. Using integrated digital networks and stored electronically programmed controlled exchanges systems, each call can be very closely monitored as to its duration and location. This of course has benefit to the telephone operator in producing a better service for the customer, but also provides more information about the customer, without the customer's consent! The fact that energy and water meters are in or around the customers' premises, effectively gives them a veto on what information they are willing to provide the supplier. The public's awareness of this intrusion into privacy may make the implementation of AMR in the energy and water utilities socially difficult.

15.2.8 The Environment

The natural environment has begun to play a bigger role in public utility management over the past few years (see sections 6.2.3, 7.2.1, 9.2.4, 10.2.3 and 11.2.4). One important way in which environmental regulation differs from economic regulation is in the role and influence of much wider political communities than the Nation-State. Take electricity generation for example. At the widest level, the Framework Convention on Climate Change is negotiated globally (e.g. the Kyoto Summit of 1997). Then the basis for discharge authorisations at individual plants have been settled via the European Union, and National Governments retain some control over the determination of national targets.

If the environment is of increasing importance in the energy market, it is crucial in the water sector. Evidence of this is that the water industries in both countries have independent environmental regulators. Laws enacted in 1964 (creating l'Agencies de Bassins) and in 1992 in France have recognised the increasing diversity of water usage and environmental needs. Meanwhile in the UK, Her Majesty's Inspectorate of Pollution (HMIP) was created in 1987, and in 1989 when the water industry in England and Wales was privatised, the National Rivers Authority (NRA), the environmental regulator, was formed. Also laws implementing international pollution control systems were embodied legislatively in the 1990 Environmental Protection Act. Finally in 1995 a new Environmental Act led to further integration in environmental policy by amalgamating HIMP functions with those of waste regulation authorities and the NRA in the single new Environment Agency, which came into existence in August 1995. At the level of the European Union, an Integrated Pollution Prevention and Control Directive was agreed in 1995, stressing the importance of integrated approaches in somewhat similar fashion to the UK's legislation. The Environmental Agency considers that the installation of metering plays a crucial role in the management of future water resources in the UK. Demand management is being encouraged to defer capital expenditure on costly production and treatment facilities. As a result, UK water companies are facing regulatory pressures to install water meters free to customers. The contrast with France, where every water supply has been metered for many years could not be more striking. This difference in metering policy highlights a cultural difference, in that water has been a much more valued resource than in the UK. The cultural difference in turn stems from the differing geographical and physical constraints that apply to both water networks. Most French water supplies are obtained from underground aquifers and many of the drainage basins such as the Loire, the Rhône and the Rhine are many hundreds of miles long. In the UK however since the drainage basins are relatively short much of the water supply comes from drainage run-off rather than underground aquifers. This means that the UK system is liable to summer droughts since water supply is loosely related to rainfall. This situation is aggravated by the lack of metering in the UK. Another effect of the nature of the UK water network is that it does not have a history of water recycling. There is no town or city less than 200km from the sea, and the sea has often been used as a dumping site in preference to recycling. In recent years the UK has had to comply with EU water quality standards and can no longer undertake such a practice. This, along with other environmental improvements, has meant that water prices have increased sharply during the nineteen-nineties. In turn, water is now beginning to be seen as a resource to be managed, and the development of metering is playing a key role in the management of this water resource.

15.2.9 Telephony in Metering Energy and Water Utilities

Some form of electronic communications link is required when 'real-time' pricing or 'time-of-use' pricing is being considered. The incumbent media of fixed telephony and radio are by far the most dominant in this area and will remain so in the immediate future (see sections 12.4 and 13.4). The lack of any communications need in Code of Practice 6 metering (see section 6.3.3) has effectively killed off any requirement for a communications media in the UK domestic electricity and gas market in the short term. Pedestrian meter readers will remain the core collection media, albeit with the help of hand-held terminals with optical or touch reading and perhaps some radio component. Power line carrier (see section 12.4.6) has the advantage that most utility consumers have an electricity supply, but distribution and transmission of electricity remains a monopoly business. This causes a dilemma for water and gas companies wishing to use power line carrier technology. This was clearly illustrated in sections 7.3.1, and 9.3.4, with EdF-GdF Services. EdF wishes to develop power line carrier technology not only to fully utilise pricing but also to provide value added services such as telephony facilities. GdF on the other hand sees less scope for 'time-of-use' pricing in gas and does not want to be tied into EdF for its communications.

Looking some way into the future, the ultimate may involve a wide band facility such as cable into the home and office and carried by entertainment companies as an added extra to their entertainment or Internet facilities. They could provide meter operations and data collection facilities. With this there may also be scope for a power line carrier within customers' premises, carrying out automatic switching and measuring appliance consumption. The use of power line carrier on the higher voltage electricity network has yet to be shown to be able to compete with copper wire and cable in such facilities as the Internet, as has recently been claimed. Nevertheless there is significant scope for increased use of this technology, particularly electricity in 'time-of-use' pricing, crediting prepayment customers and AMR. Whether this will become either economically viable or socially desirable only time will tell.

One thing is clear, metering now has less to do with metrology and more to do with the information technology business. This provides a strategic opportunity that has yet to be exploited. On the one hand, the local public utility suppliers at present have access to every household, office and factory. But at present, most domestic customers are unwilling to pay a premium for the metering and communications devices to provide, AMR, appliance switching and other added value services open to them. Meanwhile, there are cable and satellite companies desperate to obtain access to domestic premises for multimedia purposes. There is a clear synergy between these two aims, but France and the UK are approaching this in different ways.

Section 13.2.1 described how telecommunications franchises in France are almost exclusively being sold to companies who already have a presence on public utility management such as EdF, Compagnie Générale des Eaux, Suez-Lyonnaise des Eaux and Groupe Bouygues. In the UK, foreign multi-nationals with little interest in metering communications dominate the market. This is not to say that metering is not being considered. ScottishPower, Hyder and United Utilities (and others) have already a multi-utility business and have connections with the information technology suppliers (see section 12.2.5).

15.2.10 Standards and Protocols

A key to the development of the market will be standardisation. There are two extreme approaches to the development of technology standards and protocols. There is the 'top down' approach where standards are defined by Governments or regulators in legal statutes. An example of this first type of standard is the airline ticket. Every airline ticket throughout the world has the same structure and format, which is a *de juré* standard, agreed upon by an international commission. The second form is the 'bottom up' approach where a technology becomes a *de facto* standard through market mechanisms. In this case a company may patent a technology to ensure that it has the sole rights to the technology. An example of this is Microsoft's operating systems for personal computers. Microsoft through its *DOS* and *Windows* operating systems have ninety percent of the personal computer market. There is a down-side to this method of developing standards, in that the holder of the patent of the technology, such as Microsoft, wields immense market power, and as a result is facing challenges to its monopoly power in court.

In the development of metering technology in public utilities, the whole spectrum of standards formation is evident. On one side of the spectrum there are the international and national standards commissions. At the international level there is the IEC, at the European Level there is CEN and CENELEC, and at the national level there is the Electricity Pool and the Network Code in gas. At the other end of the scale there are the entrepreneurs such as Ramar and Itron who are developing new metering and communications systems. In the middle are the multi-national meter manufacturers and the utilities themselves who wield the great market power. The role that these large companies have is crucial. On the one hand, they want to influence the national and international committees on standards and at the same time they do not want to lose their market power to the new entrants. The classic example of the latter in the software industry is IBM's relationship with Microsoft. In the late nineteen-seventies IBM contracted Microsoft to develop a personal computer operating system and in effect handed over the monopoly rights to that market. Established meter manufacturers and utilities are vigilant that this does not happen in the developing metering market.

There has to be a mutually beneficial system developed between entrepreneurship, the meter manufacturers, the utilities and international standards organisations (CEN, CENELEC and IEC). Each of these parties has its own interests at stake and an entrepreneur must have space, time and financial rewards to develop new products, while regulatory supervision should ensure that everyone is working to common protocols. This is not an easy task and may possibly be addressed if an overt interest in technology R&D is considered within the regulatory process.

15.3 ANALYSING THE DEVELOPMENT OF METERING TECHNOLOGY IN UTILITIES

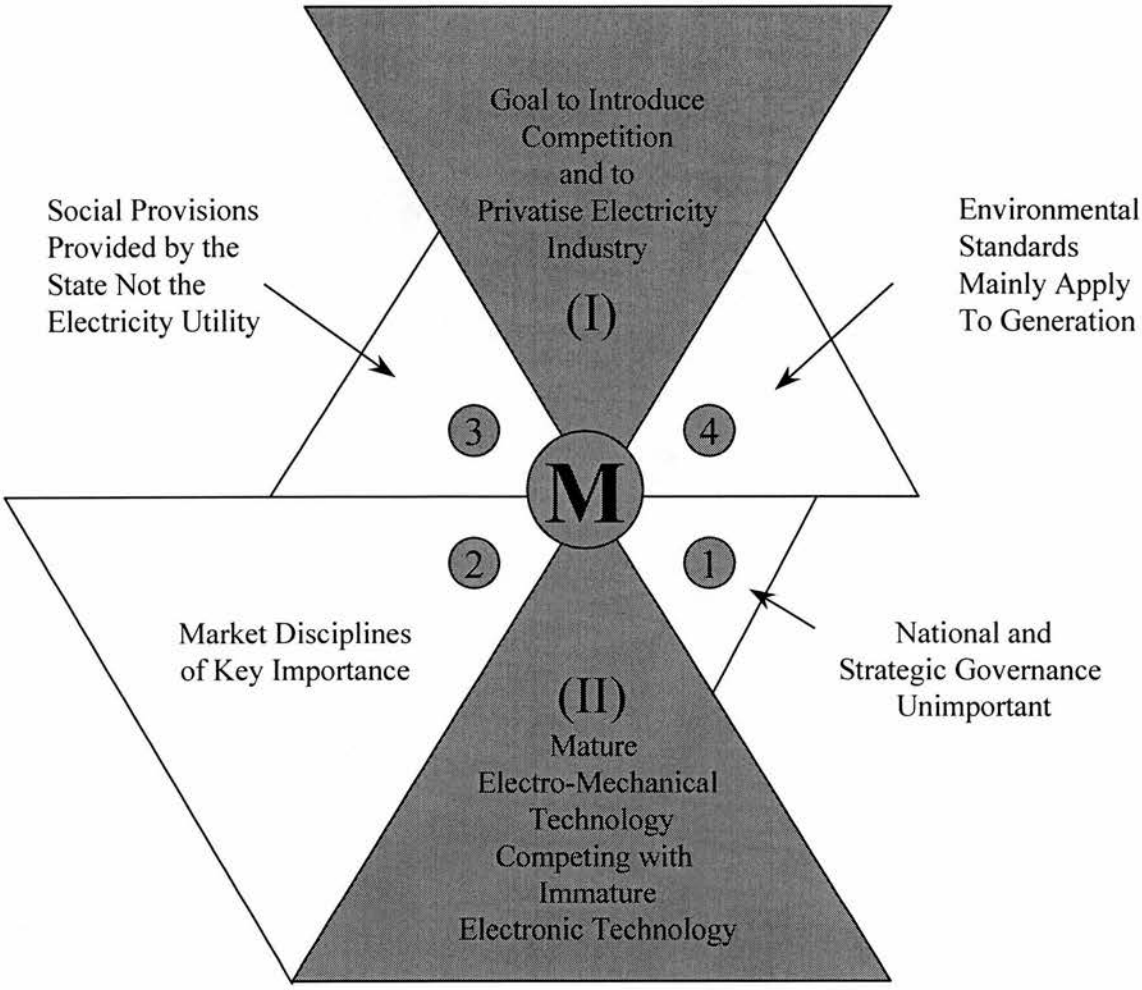
15.3.1 The Role of Theory

With the analysis of metering technology completed, it is now possible to consider a generalised analytical mechanism which may explain its development, and help guide policy in the future. This thesis argues that this requires multi-disciplinary input. *Systems Theory* (see section 5.3.1) describes how an individual piece of technology can only be viewed properly when considering the system as a whole. Further, the case studies show that the full understanding of metering could be further clarified by considering the cultural, geographical or demographical contexts. The case studies also describe how metering over the past twenty years has been changing from a metrological device to a customer service interface. To fully grasp the implications of this change in technology, a reappraisal must therefore be made of the whole system and in particular the dynamics that have caused this change. In order to do this, *Sociotechnical Constituencies* are used, since as argued in chapter 5, that this framework is most suitable when considering the changing shape of a particular technology as a result of system changes. Also the suitability of *Evolutionary Theory* will be considered when evaluating the issue of metering development in the energy and water utilities.

15.3.2 *Sociotechnical Constituencies*

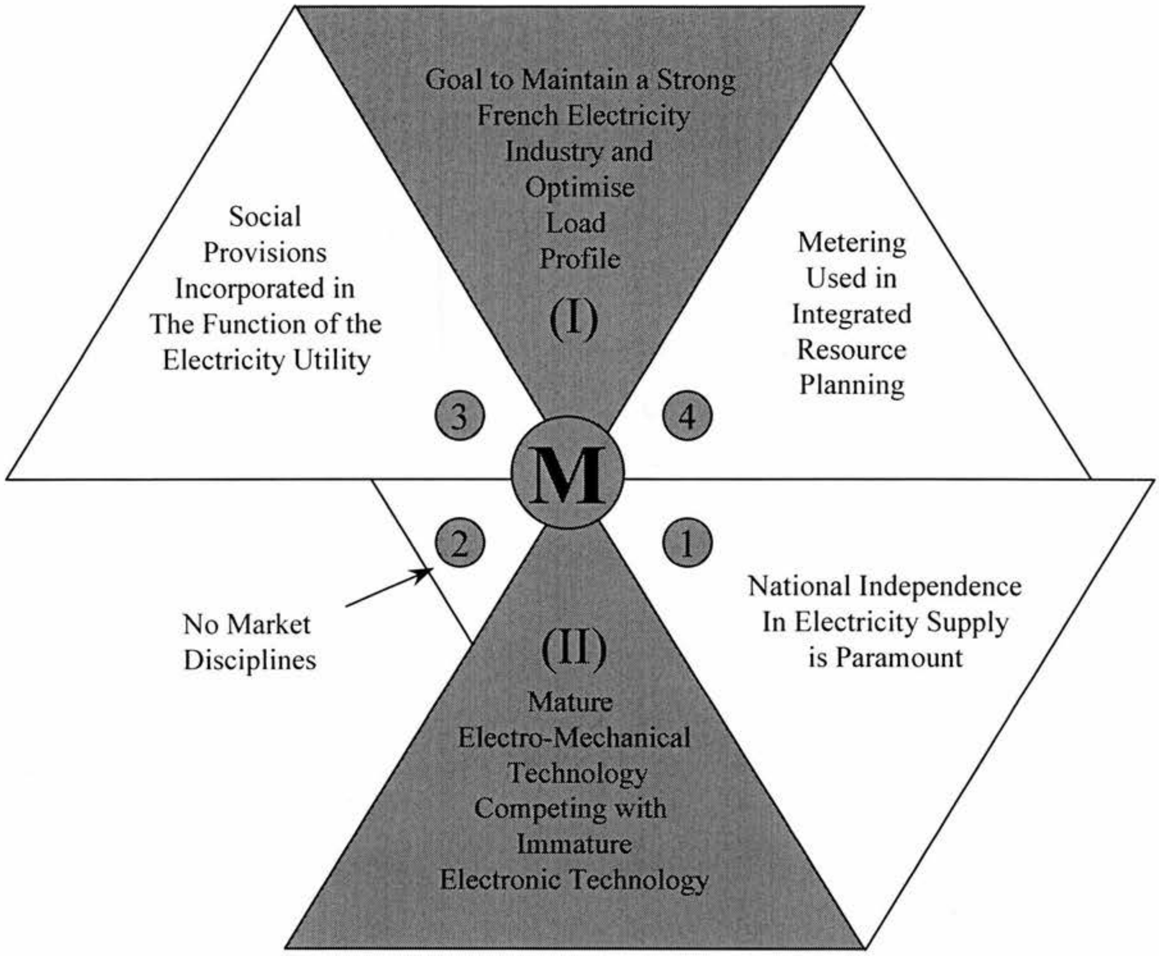
Section 5.3.2 described how technological development can be described as a dynamically changing system that aligns together in a *Sociotechnical Constituency.* Figures 16 to 21 describe such a *Sociotechnical Constituency* for each of the case studies. The concept of 'diamond of alignment' is used to illustrate the multiple dimensions involved in shaping inter-organisational contexts of metering development. The focus (centre) of the diamond is metering technology and its associated constituency. The shaded areas (I) and (II) represent the sociotechnical nature in that they are the dominant features of the constituency (I) and the technology (II). The various dimensions of the 'diamond' are then represented; 'the strategic' (1), 'the market' (2), 'the social' (3), 'the environmental' (4). The analysis differs from Molina's in one significant way in that the sizes of each portion or constituency of the diamond differ in magnitude. The sizes are proportionate to the importance that each constituency plays in the whole system. In this way, a conception of the factors that are shaping the development of metering in the electricity, gas and water industries can be developed. Thus a qualitative judgement can be made on the relative importance of market, social and environmental influences in the shaping of metering technology.

Figure 16: The Diamond of Alignment for Electricity Metering in the UK



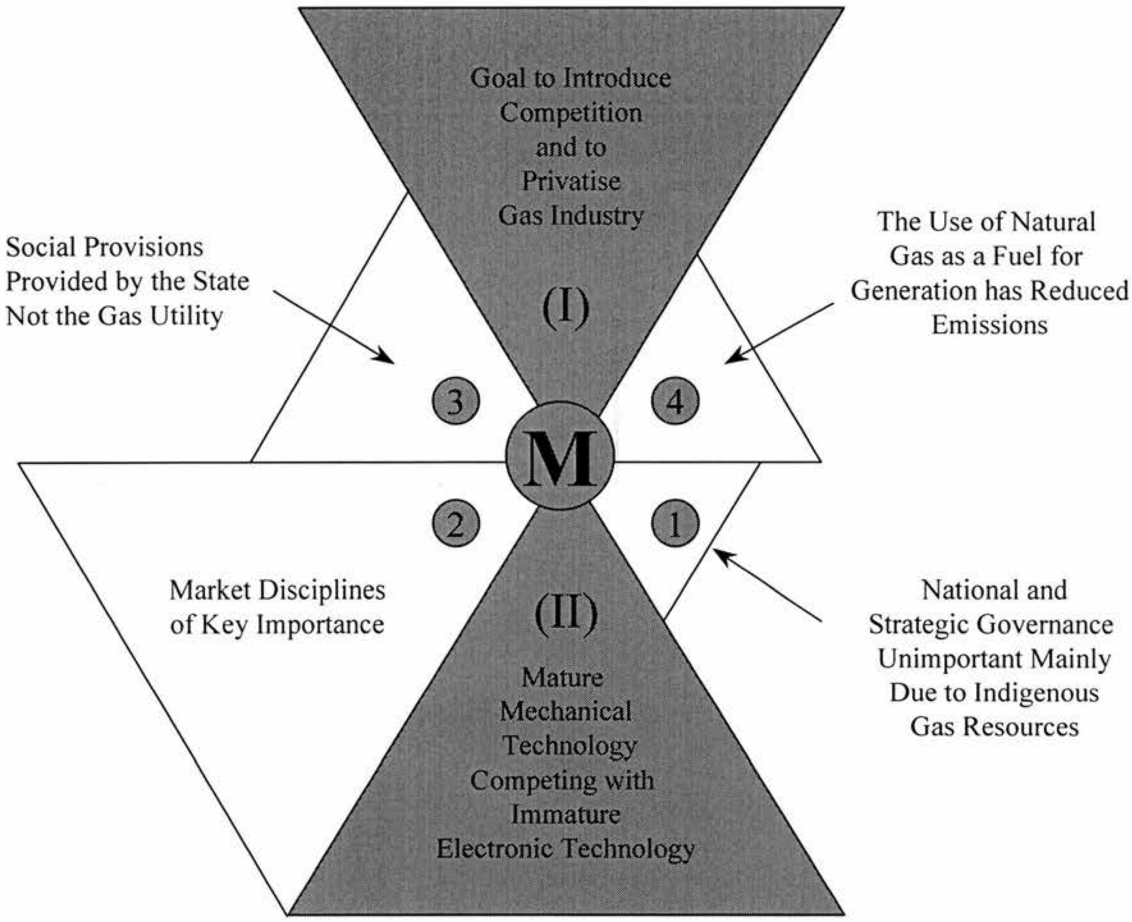
The dominant feature of the constituency for UK electricity metering (figure 16) is the introduction competition and privatisation of the electricity industry (I). In order to do this; immature electronic metering technology is replacing mature electro-mechanical metering (II). Constituency 1, which represents national and strategic governance, has largely been handed over to the market. Constituency 2 shows that the competitive or market forces portion of the diamond predominates, indicating that metering technology is primarily being developed to satisfy this constituent of the UK electricity industry. Constituency 3 indicates that social provisions are expected to be provided by the State rather than by the utility. Also the widespread introduction of prepayment metering is seen as an alternative to customer disconnections. Constituency 4 representing the environmental driver is relatively small but is certainly discernible due to emissions constraints. The Non Fossil Fuel Levy (directed at generation) is evidence of this.

Figure 17: The Diamond of Alignment for Electricity Metering in France



The dominant feature of the constituency for electricity metering in France (figure 17) is to optimise the load profile (I). In order to do this an immature electronic metering technology is replacing a mature electro-mechanical metering (II). The large size of Constituency 1 signifies that national and strategic governance is paramount in order to maintain a strong French electricity industry. Constituency 2 shows that since the industry is a vertically integrated nationalised monopoly, there is very little scope for the discipline of market forces. Constituency 3 represents that social provisions are expected to be provided by the public utility as a function of the State. Constituency 4 represents the environmental driver, which is founded in a policy for integrated resource planning through marginal cost pricing.

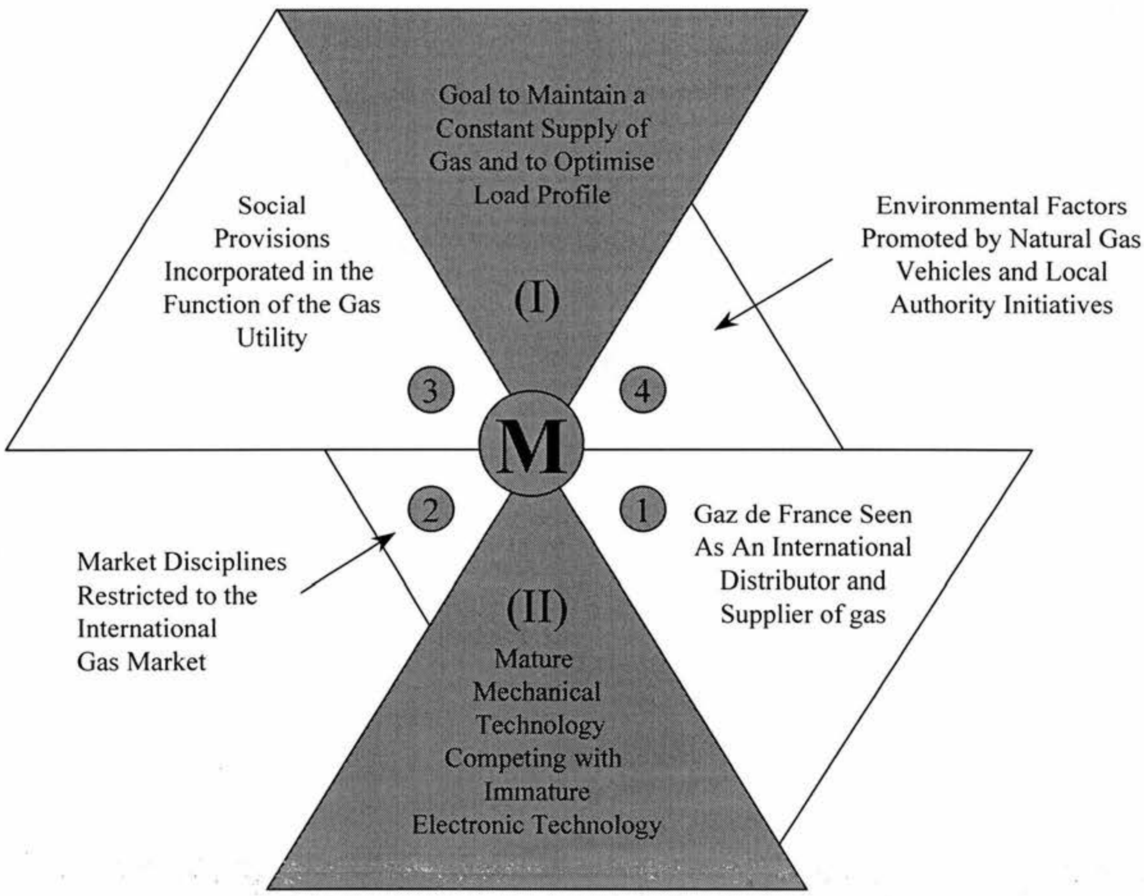
Figure 18: The Diamond of Alignment for Gas Metering in the UK



The dominant feature of the constituency for UK gas metering (figure 18) is to introduce competition and privatise the gas industry (I). In order to do this an immature ultrasonic metering technology is replacing mature gas membrane metering (II). Constituency 1, representing national and strategic governance, has largely been handed over to the market in which large indigenous resources of natural gas have played an important role. Constituency 2 shows that the competitive or market forces' portion of the diamond predominates, indicating that metering technology is primarily being developed to satisfy this constituent, as in the UK electricity industry. Constituency 3 indicates that the social provisions are expected to be provided by the

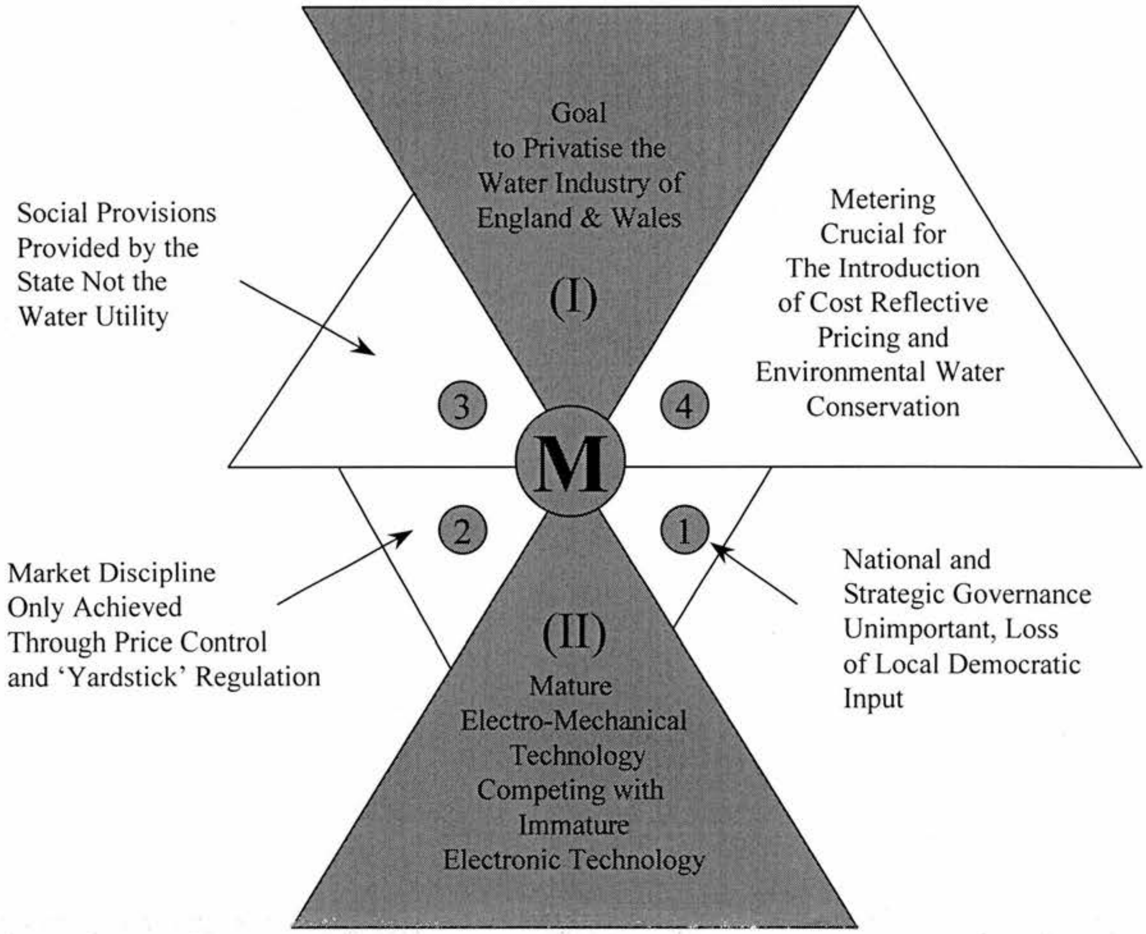
State rather than the utility. Social provisions are however addressed, to some extent, through customer service standards. There is also widespread introduction of prepayment metering. Constituency 4 represents the role that the natural gas industry has played in reducing NO_X and SO_X emissions, but with the adoption of combined cycle gas turbine generation technology rather than integrated resource planning.

Figure 19: The Diamond of Alignment for Gas Metering in France



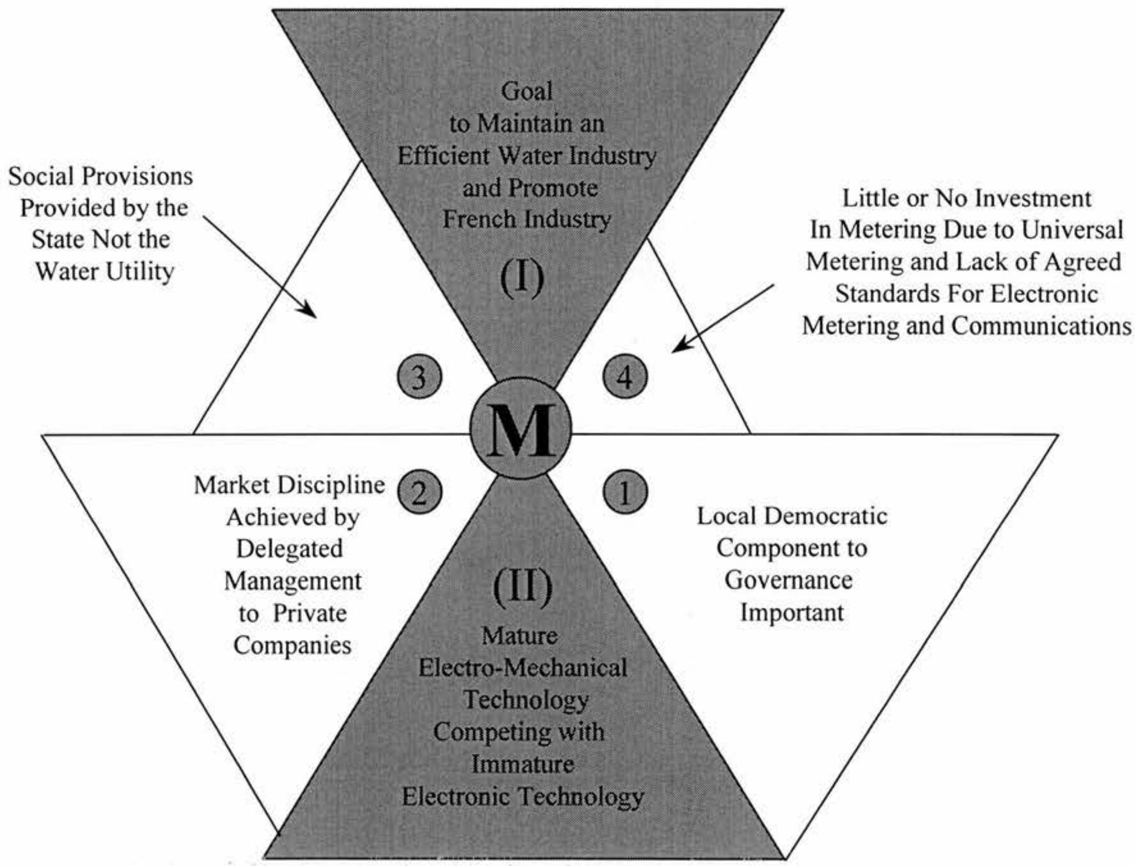
The dominant feature of the gas metering constituency in France (figure 19) is to maintain a constant supply of gas from abroad and optimise the load profile (I). In order to do this; an immature ultrasonic metering technology is replacing mature gas membrane metering (II). Constituency 1 shows that national and strategic governance is paramount since Gaz de France is seen as an international distributor and supplier of gas. Constituency 2 shows that since the industry is a vertically integrated nationalised monopoly, there is very little scope for the discipline of market forces. Constituency 3 indicates that social provisions are expected to be provided by the public utility as a function of the State. Constituency 4 shows that environmental factors are promoted by such initiatives as natural gas vehicles in collaboration with Local Authorities.

Figure 20: The Diamond of Alignment for Water Metering in the UK



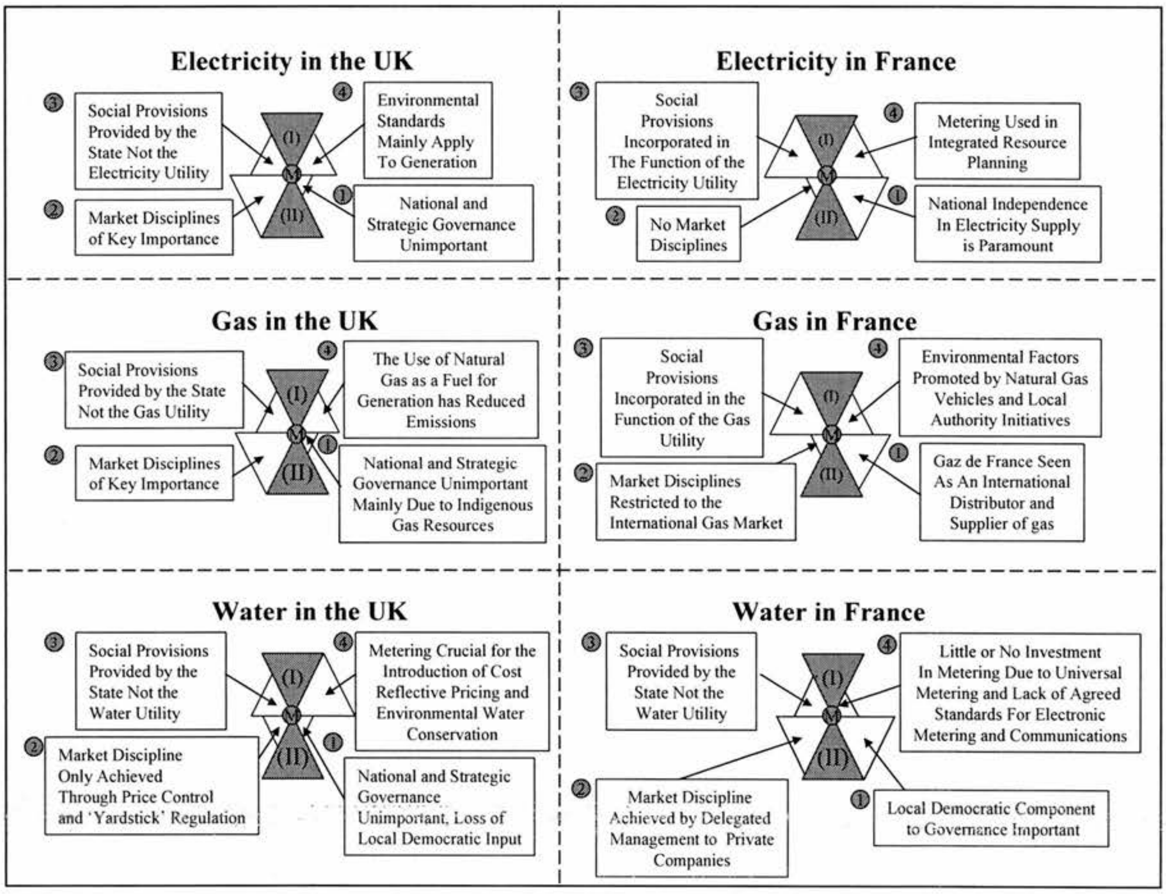
The dominant feature of the UK water metering constituency (figure 20) is to privatise the water industry (I). Until 1989 metering was rare in domestic customers' premises. Mechanical and electronic metering is gradually being introduced in England and Wales (II). Constituency 1 representing national and strategic governance, has been given little priority, which means there has been a loss of local democratic input. Constituency 2 shows that market discipline is only achieved through regulatory price controls and 'yardstick' regulation. Constituency 3 indicates that social provisions are expected to be provided by the State rather than the utility. This provision however falls short of compulsory universal metering. Constituency 4 representing environmental driver is very strong in water. Metering is crucial for the introduction of cost reflective pricing and conservation. This has become very important as a result of increasing demand and recent droughts.

Figure 21: The Diamond of Alignment for Water Metering in France



The dominant feature of the water metering constituency in France (figure 21) is to maintain an efficient water industry in France and promote French water companies abroad (I). Mechanical and electronic metering is competing with immature electronic metering and communications (II). Constituency 1 shows that a local democratic input is a very important component of the governance of the water industry. Constituency 2 shows that market discipline is directed, in many cases, to delegating the operations to private companies. Constituency 3 indicates that social provisions are expected to be provided by the State rather than the utility. Constituency 4 representing the environmental driver is very strong in water. The promotion of more 'time-of-use' tariffing is restricted by the lack of agreed standards for electronic metering and communications.

Figure 22: A summary of The *Sociotechnical Constituencies* to the Analysis of Metering in Public Utilities in France and the UK, consolidating Figures 16 to 21 in One Diagram



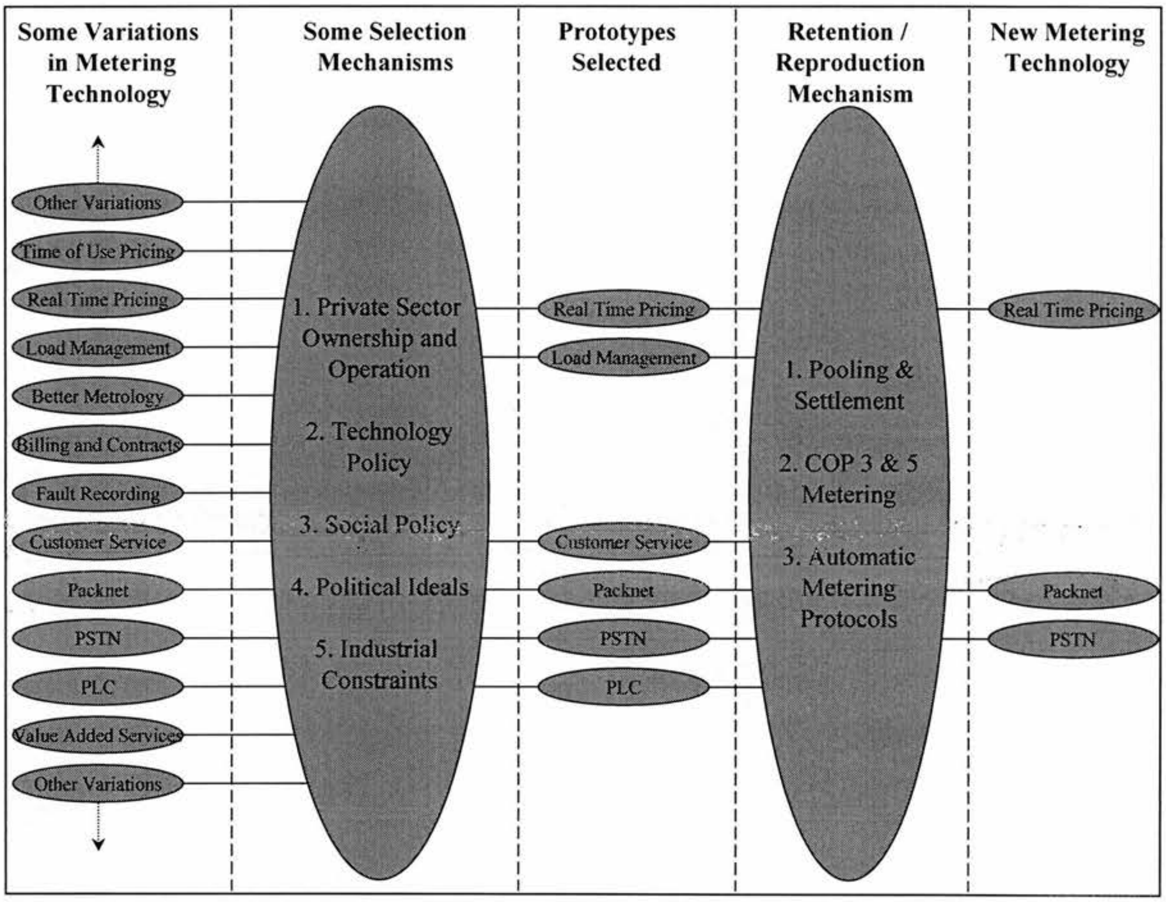
Although *Sociotechnical Constituencies* provide an excellent framework to describe the social and technical interactions of metering development in public utilities (see figure 22 for a summary diagram), it does not provide a dynamic perspective in time. In addition, the definition of *Sociotechnical Constituents* restricts the analysis to only the social and the technical. It is argued unjustified either to describe the whole mechanism as socio-technical or to limit oneself to the socio-technical. This becomes apparent when the role of physical geography is considered. The lack of indigenous fossil fuels in France and the plentiful resources in the UK has had profound and differing implications for energy supply in both these countries. Similarly the fact that France has a series of large rivers while the UK does not, has implications in the water supply of these countries. These phenomena can in no way be described as social constituents but in turn they have socio-technical implications. Thus to describe the physical constraints of each of the industries as a *Sociotechnical Constituent* is incomplete. The lack of rainfall or the difficulty in storing electricity compared with gas or water is difficult to describe in a framework that is restricted only to social mechanisms.

Finally the role of 'interpretative flexibility' leading to the diamonds of alignment outlined in this section and the eventual 'closure' of the technology requires more than acts of social negotiation. They require the implementation of standards and protocols that are codified in rules varying from international agreements, national legislation and industrial procedures of best practice. It is only when the constituency is aligned in such a way that technology in itself becomes reproducible.

15.3.3 An Evolutionary Explanation for Metering Development

An alternative, but not necessarily mutually exclusive, form of analysing technological development can bee seen through the eyes of *Evolutionary Theory* which is described in section 5.3.4. *Evolutionary Theory*, incorporating the notions of technological variation and selection mechanisms involving environmental and economic as well as *Sociotechnical Constituents*, is a second possible way of modelling the technological process. The interaction between these variables and selectors can be equated to the interpretative flexibility. The notion of retention and reproduction, which is the key to *Evolutionary Theory*, is represented by codified standards such as patents, protocols and recommendations. A proposed methodology is shown in figures 23 to 29. It has two significant differences from *Sociotechnical Constituencies*. It sets out to explain rather than describe the process of metering innovation, and it is a process that is independent of the social dimension. The variations in metering technology are represented by the metering and communications artefacts and processes. The selection mechanism is the application to which the technology can be applied. This leads to various prototypes. The prototypes are then crystallised in patents and standards that can be reproduced by manufacturers. Importantly, although the diagrams are linear this process should not be seen as linear. As described in section 5.2.1 the process of innovation and diffusion is an interactive one, and intrinsically these mechanisms tend to blend into one another in which processes like 'learning by doing' and vicarious trials are important.

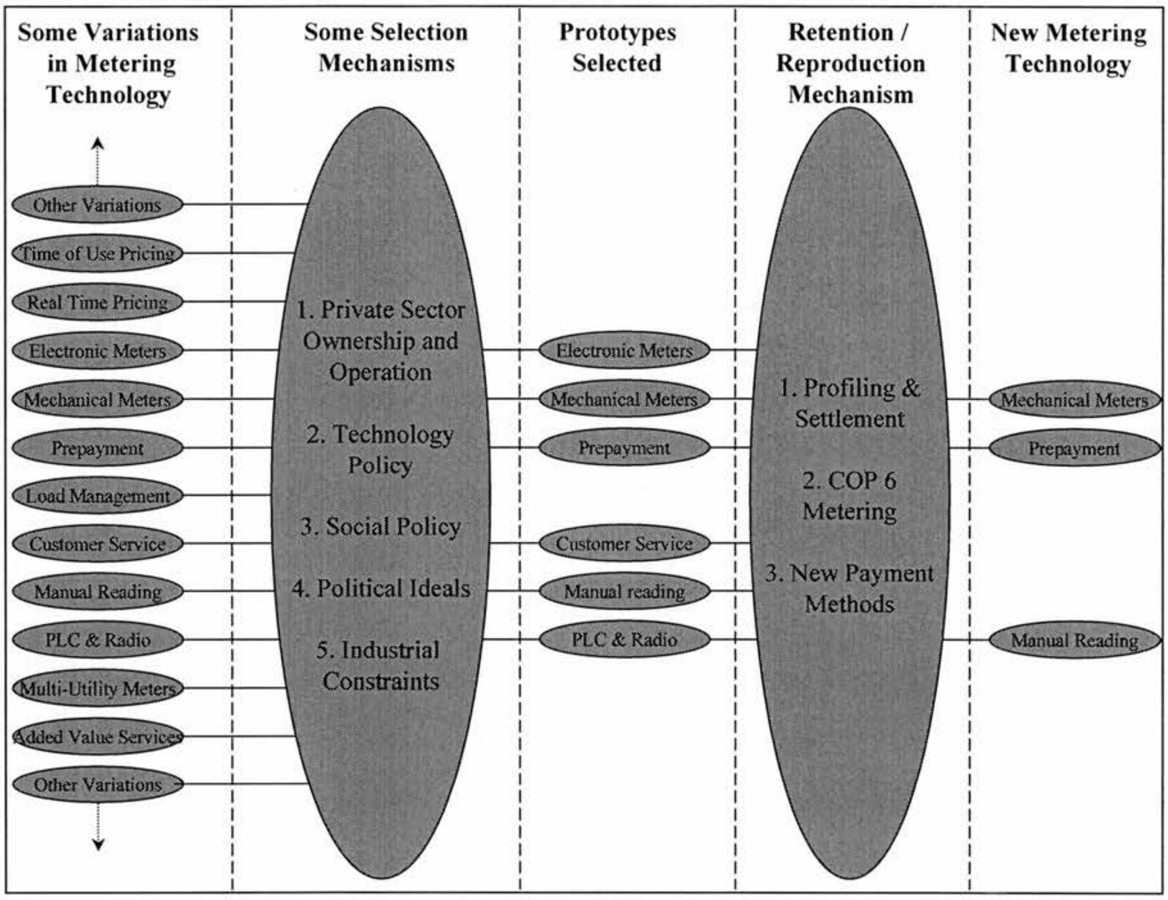
Figure 23: A Representation of the Evolution of Electricity Metering in the 'Over 100kW' market in the UK



The variations in electricity metering technology in the 'over 100kW' market are the different forms of metering technology used for metrology and communication are shown in the first column of figure 23. This includes such items as consumption, pricing mechanisms, distribution management, different forms of communication systems and value added services such as automatic meter reading. The selection mechanism involves the application of the variables to new competitive regulatory environments, improved customer service and physical infrastructure constraints, such as plentiful supplies of gas for electricity generation. This has produced new metering prototypes which are tested and then retained in standards and protocols such as the patents derived from software companies (such as UKDCS), Code of Practice 3 and 5 metering and metering data communications standards for fixed link and radio communications. These patents standards and protocols can be reproduced so that the cycle of metering evolution can begin again.

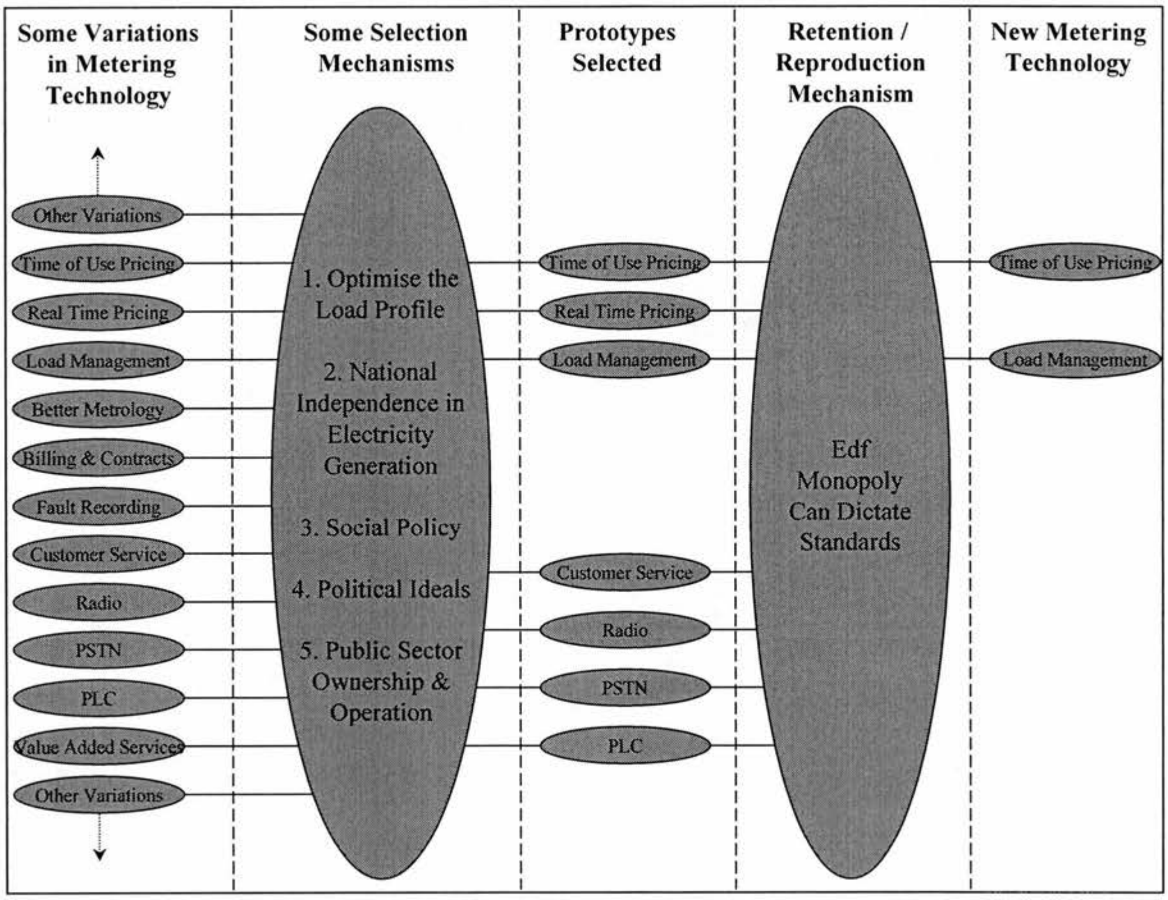
The variations in metering technology are much the same as in the 'over 100kW' market (figure 23) as with the 'under 100kW' market (figure 24) with one addition in the form of prepayment meters. Out of all these variations prepayment meters and electro-mechanical meters that read consumption only, utilising pedestrian meter reading, has been selected. The selection mechanism has also involved cost constraints in that it is too costly to install electronic metering in domestic premises. This has meant that although there are electronic prototypes, the form of metering that is retained as standard is electro-mechanical. This has been as a result of adopting profiling as a means of competition and methods of prepayment. Again, these patents standards and protocols are written down in rules and regulations so that they can be reproduced for a future generation of metering.

Figure 24: A Representation of the Evolution of Electricity Metering in the 'Under 100kW' Market in the UK



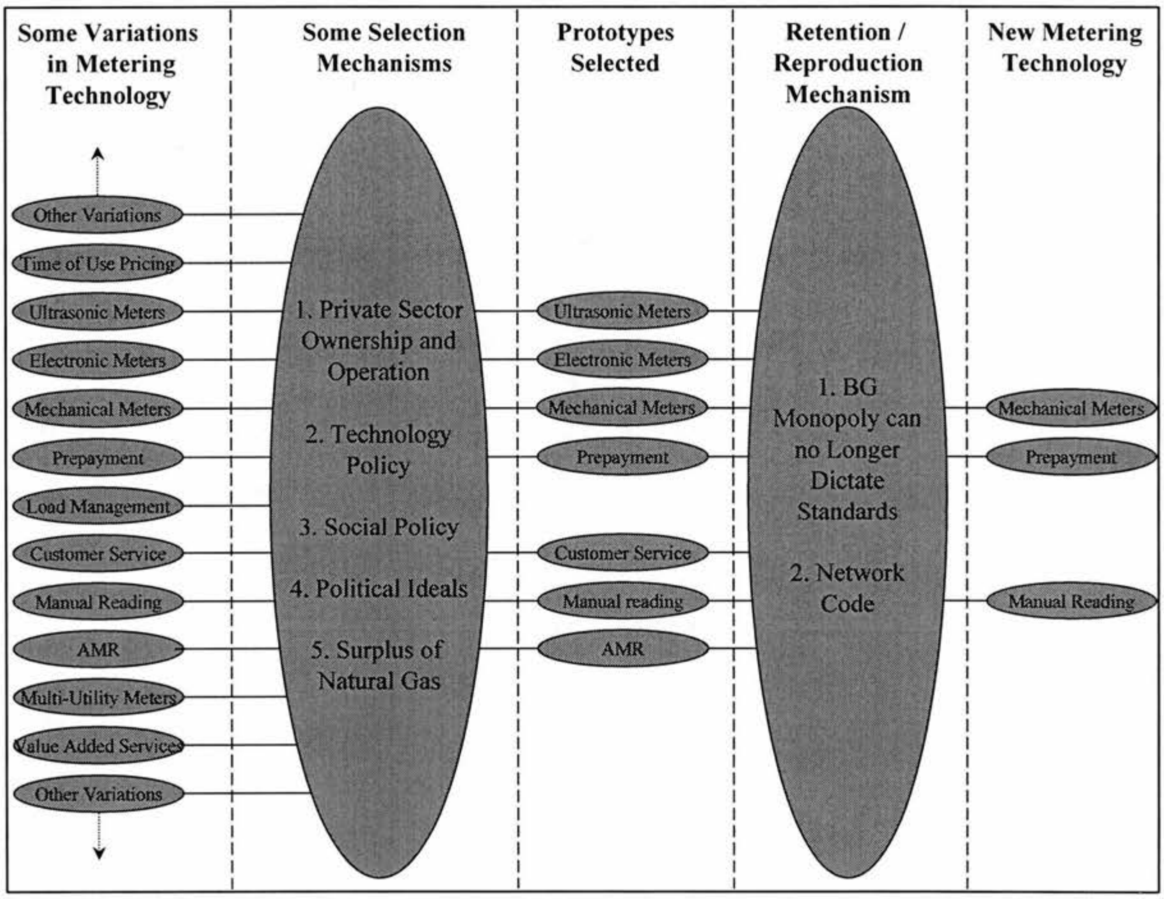
The variations for electricity metering technology in France (figure 25) are again much the same as in figures 23 and 24. Out of all these variations, 'time-of-use' metering has evolved as the predominant form of metering. The selection mechanism has involved the need to optimise the load profile through universal supply at equal cost. The form of management for pricing is retained in standards and patents which are agreed with the French Government. These patents and pricing regimes are then published, but EdF's monopoly ensures that it can dictate standards on a national level. The published prices are then reproduced or revised (or evolve) on a periodic basis.

Figure 25: A Representation of the Evolution of Electricity Metering in France



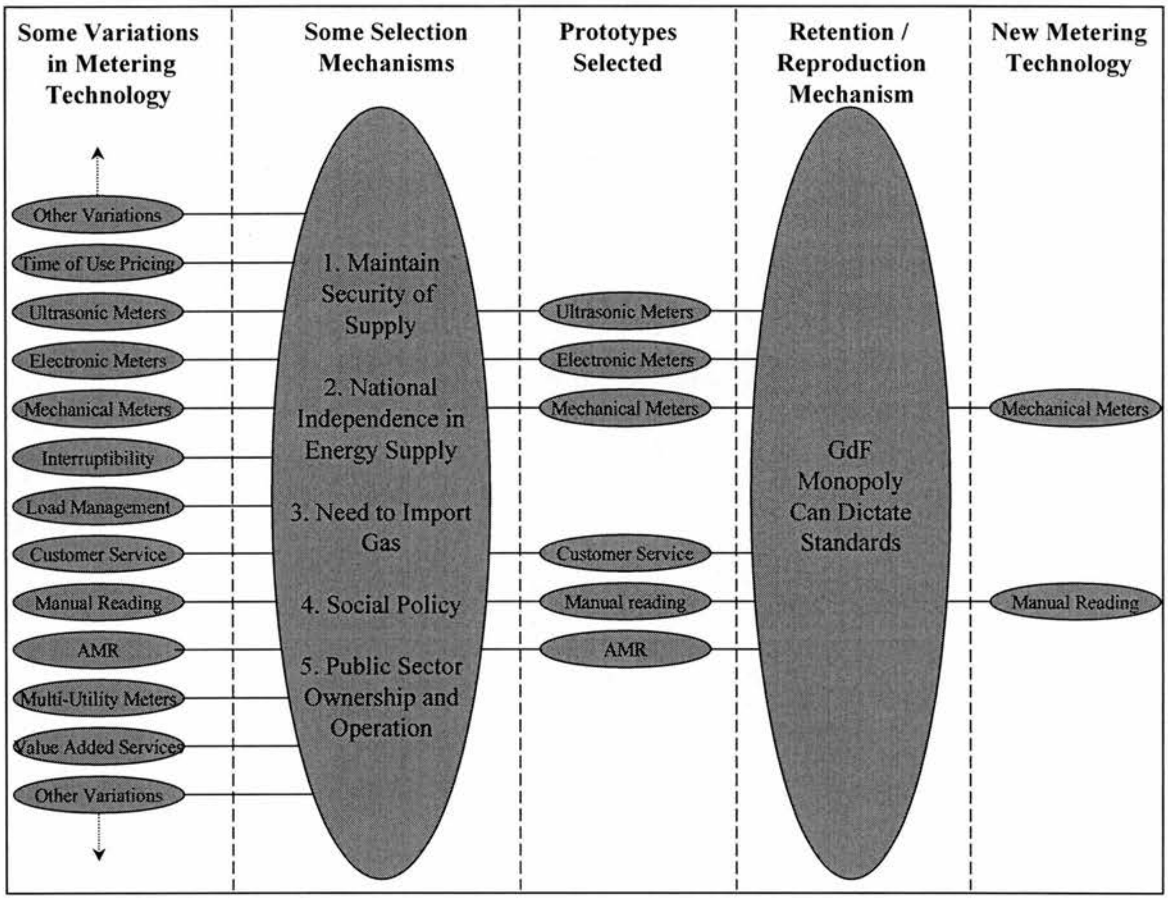
The variations in metering technology are much less extensive in the gas industry in the UK (figure 26) than in the electricity industry (figures 23, 24 and 25). Nonetheless they cover the same areas as metrology, customer service, distribution management and communications mechanisms. Out of all these variations the only developments have been in prepayment metering, in particular the *Quantum* meter, and to a lesser extent in ultrasonic metering. The selection mechanism for the *Quantum* meter has been the need to reduce disconnections. However, the fact that British Gas may soon lose their monopoly in meter operation means that the retention and reproduction mechanisms are very far from certain. If BG loses it monopoly for meter operation competitive forces may mean that the *Quantum* meter does not survive.

Figure 26: A Representation of the Evolution of Gas Metering in the UK



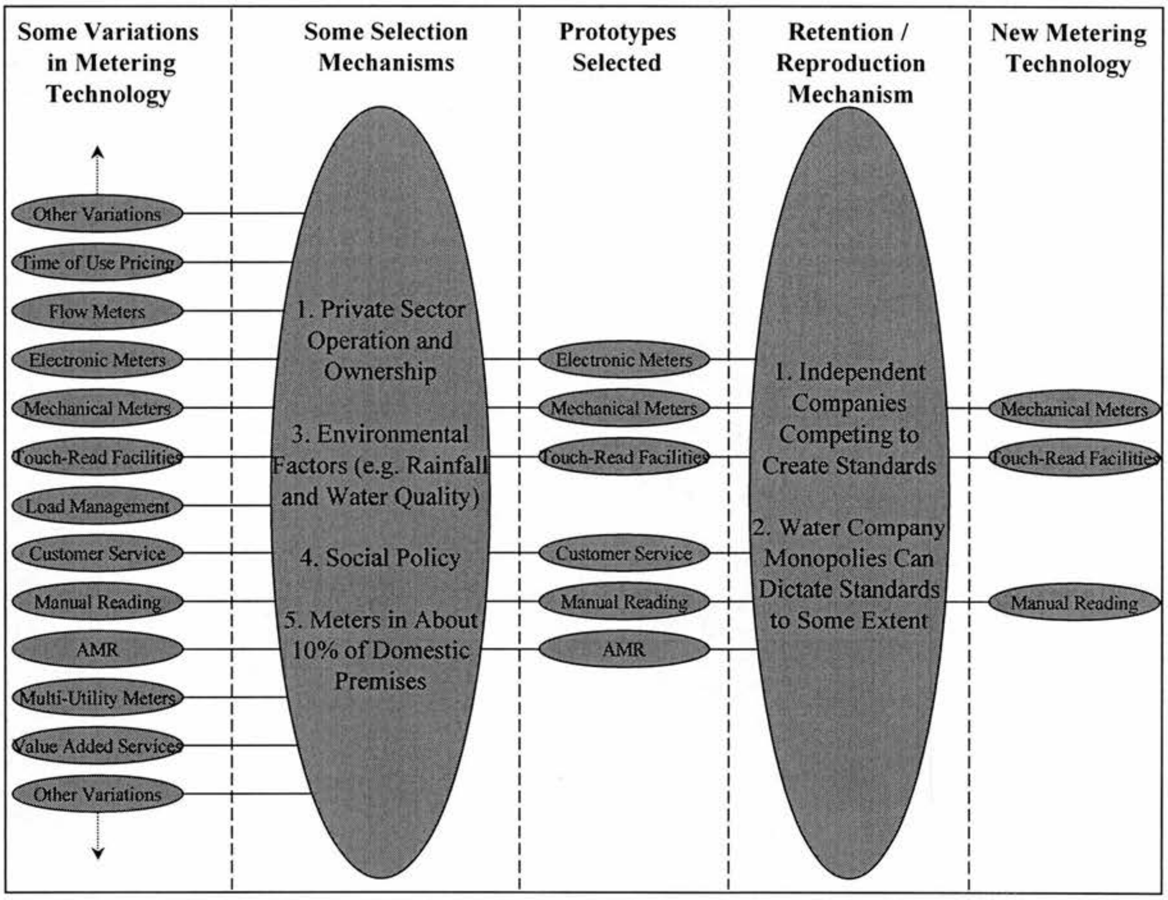
The variations in gas metering technology in France (figure 27) are much the same as in the case of the UK (figure 26). On this occasion the selection mechanism does not consist of a competitive environment. Therefore Gaz de France, through their monopoly can create retain and reproduce *de juré* standards in such technology as ultrasonic metering and thus can dictate, to some extent, the evolutionary process.

Figure 27: A Representation of the Evolution of Gas Metering in France



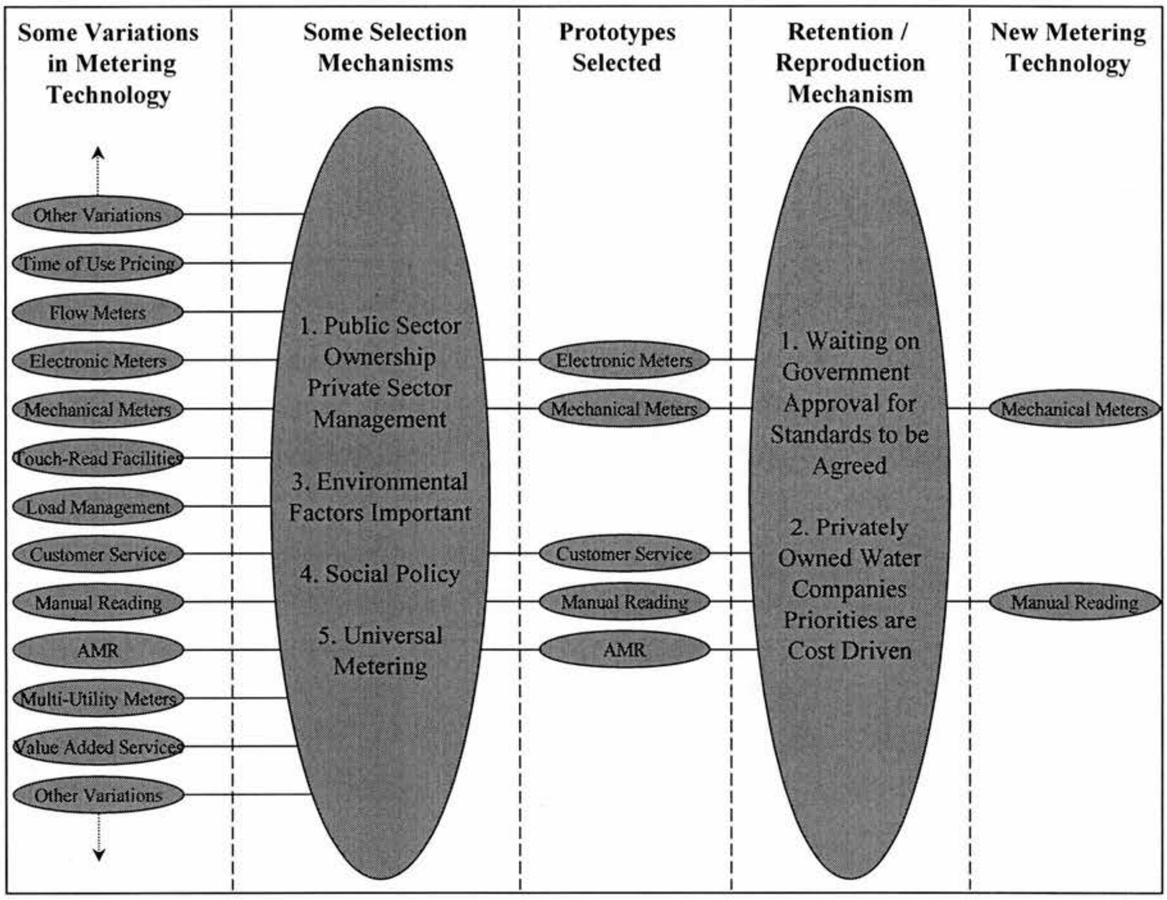
The variations in metering technology in the UK water industry (figure 28) involve: consumption by volume or demand by flowrate; pricing; distribution management; leakage and demand management. On this occasion the selection mechanism does not consist of a competitive environment although infrastructure investment is a key factor. The industry consists of an economic regulator who wishes to see cost reflective pricing and an environmental regulator who wishes to see water conservation. On the other hand, consumer groups are largely hostile to metering. The final form that metering will take is uncertain. The retention mechanism involves legislation which encourages metering, patents on new electronic meters and new communications protocols such as DLMS, *Flag* and *CHIRPS*.

Figure 28: A Representation of the Evolution of Water Metering in the UK



The variations in metering technology in the French water industry (figure 29) involve much the same as in the UK (figure 28) but one important factor is different. In France there is almost universal water metering. Since there is no stimulus to install new metering, much of the selection mechanism depends on the wishes of the Local Authorities and private water companies. Thus there is little stimulus for the evolution of water metering in France. The retention mechanism is therefore far from certain. These prototypes have yet to be developed, and standards have yet to be agreed. This means that the reproduction of 'solid state' water meters cannot take place.

Figure 29: A Representation of the Evolution of Water Metering in France



The key features of this evolutionary description of the metering technology system are three fold. Although the system is bounded its variables and selectors can be added or subtracted depending on the dynamics of the system. That is to say although a number of variables and selectors have been highlighted, this is not to say, that other selectors and variables are not involved in the process. In addition the variable and selectors will vary in importance in both time and space with new factors entering and others disappearing. For example, environmental legislation has grown in importance over the past twenty years. Similarly, new innovations in microprocessor and communications technology are introducing a distinct new dynamic not only for metering technology but for system infrastructure as a whole. Finally this is an interactive process where variables are influencing the shape of selectors and selectors are influencing the shape of variables.

15.4 METERING POLICY

With the illumination of the issue of metering technology that the *Sociotechnical Constituencies* and evolutionary approaches provide, some judgements can now be made on metering policy. *Sociotechnical Constituencies* show that technology development is not a product of one process but many. Thus the policy of the UK Government on the creation of a market in electricity and gas, has resulted in a metering technology which is geared primarily for trading needs. Similarly the French Government's policy of independence on energy resources has resulted in metering which is specialised to optimise the load profile. Another important feature that is also revealed, is the role that metering has placed in achieving certain political and economic goals. In the UK, it has been used to introduce competitive trading arrangements, while in France it has been a key factor in maintaining the integrated monopoly status. An evolutionary approach introduces a time dynamic to the analysis of metering development and provides an explanatory mechanism for the events taking place. Moreover, evolution provides a less overtly social analysis where the variables can be random, socially constructed or 'naturally' occurring. The analysis also shows that metering technology can be used for socio-political ends when its development involves a complex mixture of random, natural and social circumstances. *Constructive Technology Assessment* (see section 5.3.4) is a promising methodology in which the regulation of metering technology can account for both consumers' and producers' interests. Take for example the development of water metering policy in the UK. It is clear that both the economic regulator (Ofwat) and the environmental regulator (the Environment Agency) would like meters installed in all households. Yet this is opposed by consumers' committees who argue that water saving devices should be installed first before metering is considered. Any policy on water metering should take into account all these constituents.

15.5 CONCLUSION

This chapter has described the development of metering technology in the French and UK electricity, gas and water utilities. In concurrence with *Systems Theory*, it is viewed that innovation in metering can only be understood as a component of the network infrastructure as a whole. It has also been discovered that the role of metering in the network infrastructure of public utilities is undergoing a process of change. It is changing from a metrological device to measure the quantity or quality of the product to an active customer interface. This change has been chiefly brought about by the revolution in microprocessor technology. It is therefore concluded that since a component technology such as metering is changing, then the infrastructure around that technology must be either driving, or responding to, the innovation. An analysis of this regulatory change is made in the next chapter.

Sociotechnical Constituency and evolutionary approaches were used to describe the constituent elements involved in this change, and how they have resulted in different technological and infrastructure solutions for metering technology. It was shown that the differing *Sociotechnical Constituents* across utilities and between countries proved to be powerful drivers to differing 'interpretative flexibilities' between the sectors studied. In this way a description of metering technology could be carried out and a comparison made between industrial sectors. *Evolutionary Theory* on the other hand explained how standards codified in patents, protocols and legislation were powerful mechanisms of technological crystallisation and system closure. Thus it is by these mechanisms that a particular meter or artefact can be reproduced on a large scale. Evolution also presents a time dynamic and opens up the analysis to non-social as well as social constituents. In this way the *Sociotechnical Constituents* became selectors incorporating random and non-social events.

It is not suggested that any one of the concepts discussed in this analysis alone can describe the process of change occurring in utility metering. Each approach is better at describing different aspects of the system. *Systems Theory* is useful, predominately when describing the role of metering technology within a large infrastructure. *Sociotechnical Constituencies* highlight the forces that drive change in the technological and infrastructure system. Finally, *Evolutionary Theory* can provide a wider dynamic that incorporates the role of time in the process that can be used in a descriptive analysis, and as a tool to aid technology policy. The validity of this pragmatic and eclectic approach to the use of theoretical frameworks is justified in section 17.2.

CHAPTER 16

REGULATION IN UK AND FRENCH UTILITIES

16.1 INTRODUCTION

It is now appropriate to begin the analysis of the impact of this research on regulatory policy. Section 4.4.1 discussed the various forms of the *Principal-Agent* model for the regulation of public utilities. The case studies have provided empirical evidence of the ways that the *Principal-Agent* model is structured for public utilities in France and the UK. Chapter 14 concluded that information technology has, to varying degrees, influenced changes or modifications in the *régime of régulation*, while chapter 15 examined ways of conceptualising a change in metering and communications technology. This chapter will now discuss further the modes of regulation explored in the case studies and how they have changed over the past twenty years under the influence of various actors. As in the previous chapter, methods of analysing this change will be presented, and recommendations will be made, on future regulation policy. On this occasion *Techno-Economic Networks* and *Evolutionary Theory* are used in an attempt to describe and explain the change in the regulatory process.

16.2 MODES OF REGULATION

16.2.1 Deregulation

The argument for deregulation rests on the notion that the gains from scale economies and price or profit control are small in relation to the inefficiencies of regulation. In other words, the logical and empirical foundations of common carrier and public utility regulation are too shaky to support its existence. A number of deregulatory alternatives were considered in section 4.4.6, namely; unregulated monopoly, self-regulation and pseudo-competition. Pseudo-competition perhaps best describes the situation currently existing in the UK and French telecommunications, following the divestiture of British Telecom (total) and France Télécom (partial) by their respective Governments. Here apparent competition and regulation exist simultaneously. Monopolies still exist, with first mover advantages arising from sunk investment. Therefore some incentives by means of regulation or subsidy are needed to promote entry. So active regulation is required to encourage competitors to enter the market. British Telecom for example, has been prevented from competing in the home entertainment market until such time as the cable companies have a sufficient market share so that they can compete with BT. Competition is also being introduced in France where EdF and SNCF are being encouraged to use their networks for telephony. Another indication that there is only pseudo-competition is that British Telecom and France Télécom are still *de facto* monopolies subject to regulation. For instance, BT's prices and customer service standards are set by the independent regulator Oftel. The Governments of the two countries also still take an interest in the social impact of the telecommunications infrastructure development. Evidence for this is that the 'National Grid for Learning' which aims to have every school and library connected to the Internet. Despite all these outside controls however, competition is developing in France and the UK. The reasons for this are complex, but in Chapter 14 it is suggested that the development of information technology is a major contributor to the process.

16.2.2 *Third Party Access*

Third Party Access used in the electricity and gas transportation sectors in the UK (see chapters 6 and 8) can be seen as an intermediate stage between deregulation (see section, 4.4.6) and the regulation of private monopolies (see sections 4.4.3 and 4.4.4). It involves competition or pseudo-competition in the production and supply components, combined with the *Principal-Agent* model for the monopolistic transportation component. In the UK the *Principal* is a semi-autonomous economic regulator (Offer or Ofgas) while the *Agents* are privately owned monopolies. In this system, a gas or electricity supplier will pay the transportation companies (the Regional Electricity Companies for electricity and TransCo for Gas) and a fee for the use of their transportation system. In turn, the supplier adds this cost to the production and administration costs, and charges the customer. The monopoly transportation companies are regulated by means of a price cap (RPI-X) imposed by the regulators.

16.2.3 *Single Buyer Procedure*

With the *Single Buyer Procedure*, one company is responsible for buying all the electricity and gas requirements over a particular franchised area. Chapters 7 and 9 described that this system operates in France where Electricité de France and Gaz de France are responsible for buying all the respective electricity and gas for France. So this develops an inter-country trading market, rather than an intra-country trading market as in the UK. The *Single Buyer Procedure* can be seen as a modification of the public enterprise form of regulation described in section 4.4.2. Under pressure from the EU to liberalise its energy market, France has been forced to reconsider its energy supply policy. The result was the adoption of both the *Single Buyer Procedure* (to satisfy France) and the *Third Party Access* system in European Law.

16.2.4 The Delegated Management Model

The 'franchising out' or 'delegated management' model described in chapter 11 is used for about seventy per cent of the water supplies in France. In this form of regulation, administration, and in some cases the capital expenditure of publicly-owned municipal water supplies are delegated to private companies on a competitive tendering basis. This introduces a market element into water supply while leaving the ownership of it in the hands of the local municipalities. This is a half-way house between public and private administration that provides some sort of competitive discipline. In addition to Local Authority regulation, there is also regional and national regulation of water in particular, with respect to the environment. This is administered through *l'Agencies de Bassins* (AdB) and the Ministry of the Environment.

16.2.5 The Regulation of Private Monopolies

The regulation of private monopolies applies to the water industry in England and Wales (see chapter 10). A public owned and operated monopoly owns and runs the water supply and treatment facilities for a designated area. It is similar to *Third Party Access* in that it is regulated by means of a price cap (in this case RPI+K). But, unlike the gas and electricity industries, there is no integrated 'National Grid' for water. Thus *Third Party Access* cannot operate. Thus an economic regulator (Ofwat) who has a number of duties including setting price controls and evaluating customer service standards regulates the industry. The regulatory controls are set by a form of 'yardstick' regulation where the performance of regional monopolies are compared in a league table format. The water industry in the UK is also controlled by The Environmental Agency, which has duties similar to the AdBs in France.

16.3 ANALYSING CHANGES IN THE REGULATION OF PUBLIC UTILITIES

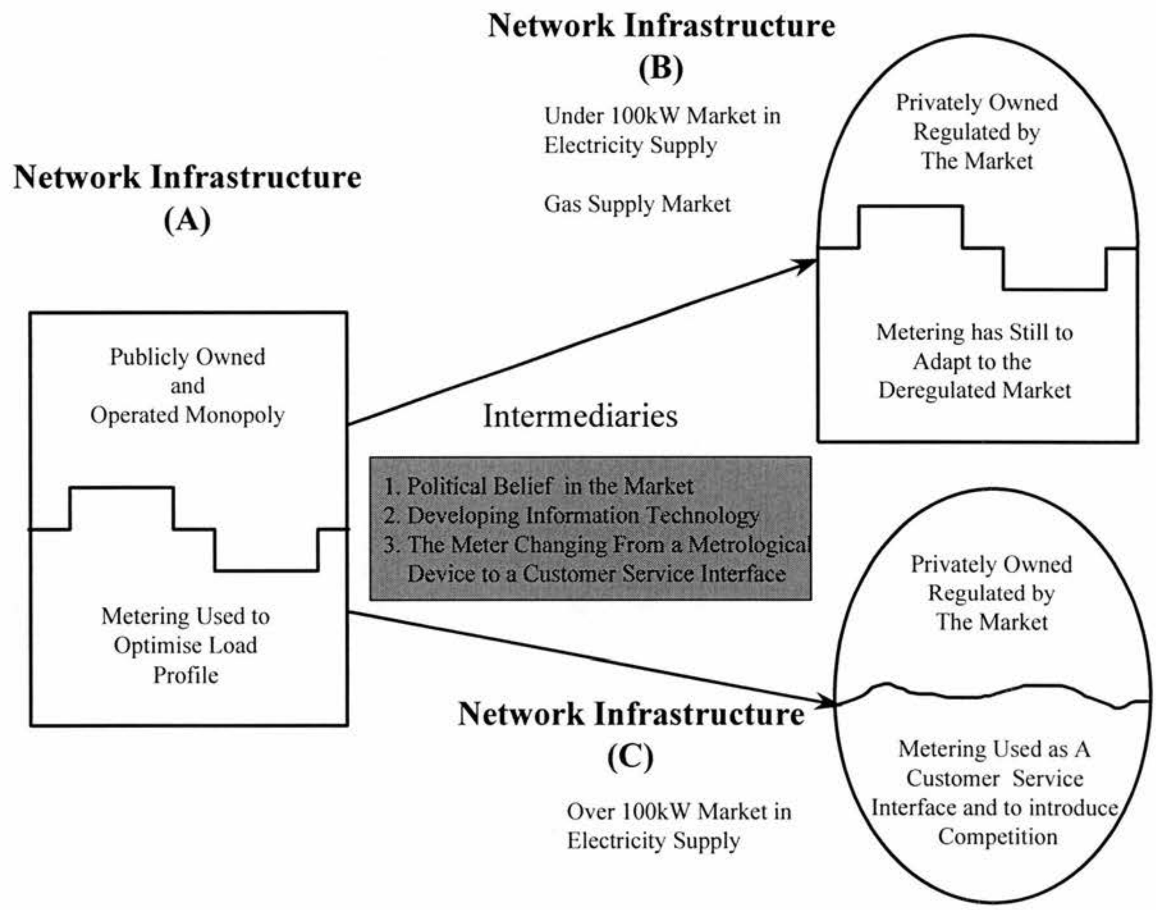
16.3.1 The Role of Theory

As with the last chapter, *Systems Theory* is again used as a suitable starting point to consider the regulatory process. Thomas Hughes describes the development of the electricity power network as a 'seamless web' where individual artefacts are part of an interweaving sociotechnical system. Hughes' form of *Systems Theory* is therefore helpful in describing how information technology can fit into the system as a whole. Where *Systems Theory* is less helpful, is in the role of information technology as a dynamic for change from one regulatory system to another. Chapter 5 described how *Techno-Economic Networks*, *Sociotechnical Constituencies*, and *Evolutionary Theory* can address such system change. When relating this to regulatory change, the case studies have shown that technology is only one of many components in the regulatory system. This analysis then differs from the analysis of metering development in chapter 15 in that it is focusing on the regulatory system as a whole, rather than metering specifically. For this reason it is inappropriate to use the techno-centric technique of *Sociotechnical Constituencies* to describe regulatory change. In this sense, it is found that the more neutral vocabulary of *Techno-Economic Networks* and evolutionary theory proved to be more fruitful in the analytical process.

16.3.2 *Techno-Economic Networks*

The act of change of a regulatory system stems from numerous interactions between diverse actors and intermediaries, both human and non-human, acting upon a relatively rigid system. An actor can be seen as a component of a *Techno-Economic Network* whereas an intermediary can be described as an actor which, is a contributory factor, in the change from one *Techno-Economic Network* to another. The exploration of case studies highlighted a number of these actors. Chapter 14 then argued that information technology was the prime mover in the deregulation of the telecommunications industry in both France and the UK. But the analysis also suggested that in the gas and electricity utilities, information technology played a lesser role in that it was reduced to only a facilitator in the change. In other words information technology along with geopolitical and sociological factors were major factors to the innovations and system changes occurring in these industries. By contrast the information technology revolution had hardly touched the water industry which had more important drivers such as environmental factors affecting it. The notion of a *Techno-Economic Network* has been found to be useful as a tool for the analysis of the outcome of a system which is constructed from a number of actors. Moreover with this approach one can analyse the interactions of metering technology as well as other social and non-social actors with the regulatory system.

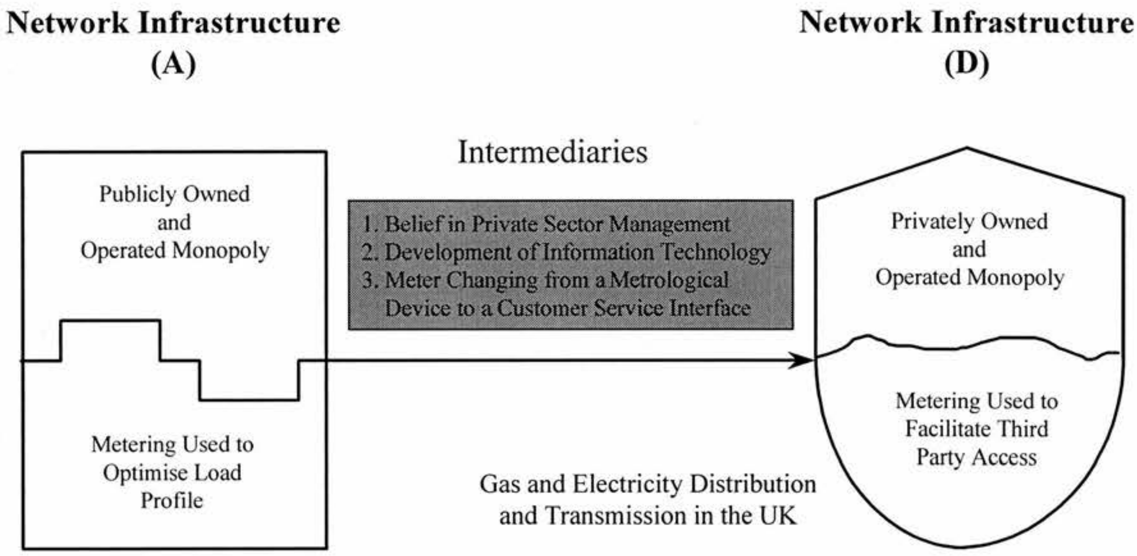
Figure 30: A *Techno-Economic Network* Depicting Deregulation in the UK



The deregulation process that has occurred in the UK (see figure 30) has been dependent on a number of *intermediaries*. A major one has been the rise to political prominence of people who believe that market devices and entrepreneurial profit are preferable to neo-classical welfare economics. They envisage that the sole role for Government is to correct for issues not addressed by the market system such as social equality and imperfect competition (see section 3.2). Another feature of deregulation and *Third Party Access* (see also figure 31) has been the necessity to build a large information technology infrastructure. In the UK electricity industry the Pooling and Settlement System for customers over 100kW and the Initial Settlement and Reconciliation Agent (for customers under 100kW) allow competitive trading in the generation and supply markets. This would be inconceivable without new systems of electronic data interchange. Similarly the Network Code in the UK gas industry has also allowed competitive trading. Thus, one of the notable features in the deregulatory process has been the investment in information to allow trading to take place. This in turn is changing the traditional role that metering has had as a metrological device and converting it into a customer service interface (see section 12.4.7). Thus *Techno-Economic Network* (A) which was a vertically integrated publicly owned and operated monopoly, and which used metering to maximise load factor, has been transformed into two new *Techno-Economic Networks*. The network changing from a rectangle to an oval shape in figure 30 depicts this change. *Techno-Economic Network* 'B', represents the electricity supply market under 100kW and the gas supply market in the UK. These supply markets have been unbundled from the transportation and production functions and are now privately owned and are (or soon will be) open to competition. Yet the 'under 100kW' market old metering technology is still being used. Electro-mechanical meters, which were being used under the old régime, have not yet adapted to the new system. This indicates that the *Techno-Economic Network* has yet to take over the process of *irreversibleisation*. In other words it is still immature and unstable. *Techno-Economic Network* 'C' however is much more stable. This represents the electricity market over 100kW in the UK. Here metering and communications technology has adapted to the new régime and features such as 'real-time' pricing, automated meter reading and load management have become a reality.

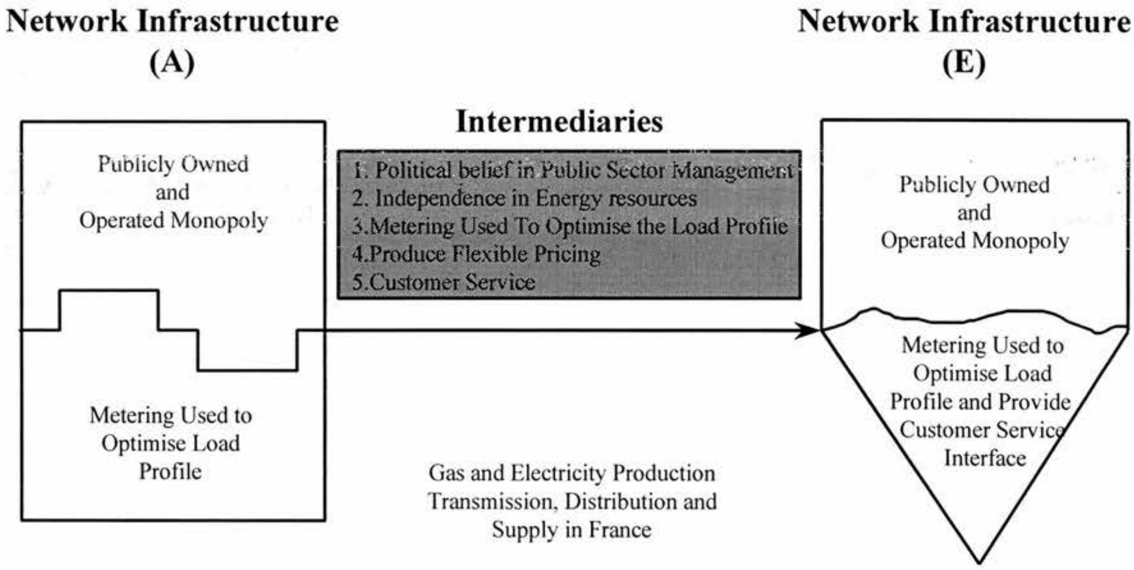
In the distribution and transmission functions of the gas and electricity industry in the UK, *Third Party Access* has been introduced (*Techno-Economic Network* 'D' in figure 31). The *intermediaries* in this case, as depicted in figure 30, have been a belief in private sector management. However in contrast to figure 30, these functions are still natural monopolies, and a form of price regulation (RPI-X) has been introduced. Again information technology has played a crucial role in the ability to transfer customers from one supplier/shipper to another and calculate 'use-of-system' charges in order to allow competition to develop in the energy supply and electricity generation markets. The role of metering is at the centre of this process in the settlement arrangements that administer the *Third Party Access* process. Again the changing 'shape' of the network and the role that metering plays is depicted by the differing shapes in the diagram.

Figure 31: A *Techno-Economic Network* Depicting the Introduction of *Third Party Access* in the UK



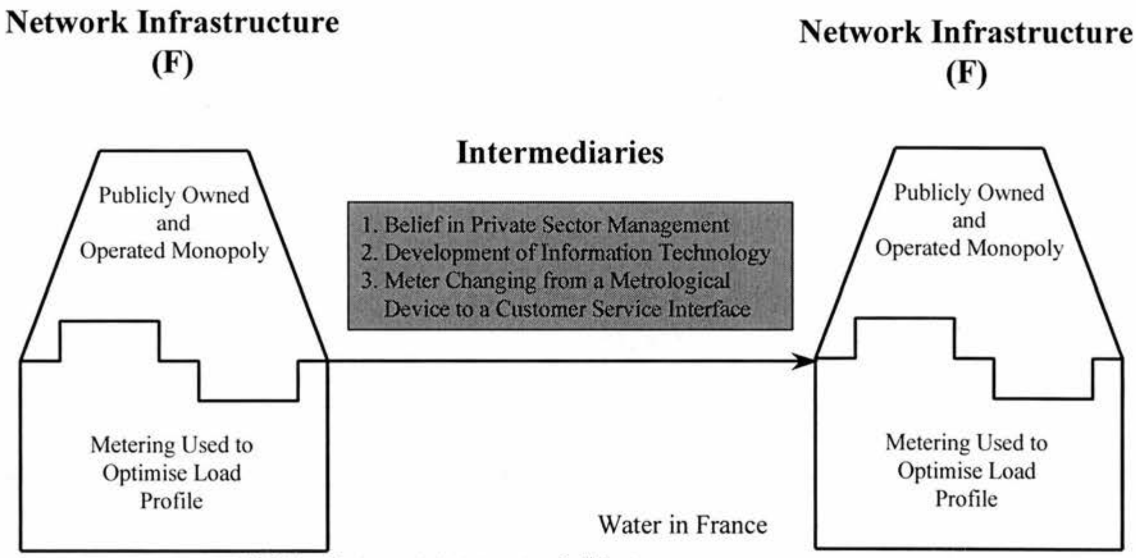
As with the electricity and gas networks in the UK, the energy infrastructure in France was (and still is) a publicly owned and operated vertically integrated infrastructure where metering is used to maximise load factor (*Techno-Economic Network* 'A' in figure 32). But in contrast to the UK this network structure has been largely retained but remoulded into the *Single Buyer Procedure* through a process of 'modernisation' and 'mobilisation' (see section 7.2.7). This has resulted in the infrastructure *closing* round *Techno-Economic Network* (E) in figure 32. The *intermediaries* in this process have mainly been political. A key actor has been the French State. France has a reputation of being a *dirigiste* State, in that it is more interventionist and protectionist of its industry than the UK. Its poverty in natural resources has meant that France was exposed to the full brunt of the oil crisis in the nineteen-seventies. This, and the close association between the State and industry, were the major reasons for investing in nuclear generation technology at that time. This policy has meant that France is now self sufficient in, and is indeed a net exporter, of electricity. As a consequence the country is now very insulated against external fluctuations in energy price. On the down side, the country's energy policy is committed to one form of technology, namely nuclear power. This has clear implications for regulation of energy policy in France. If the French Government allows *Third Party Access* to its network to a competitive generation and supply market like the UK, the whole of the French energy policy would be compromised. Thus there is a belief that public sector management of energy resources is best. In this belief, the fact that France wishes to have independence in energy resources and metering technology is being used to maximise the efficiency of the vertically integrated system through flexible pricing and increased customer service. The fact that *Third Party Access* is being introduced in many other countries in the European Union suggests that this infrastructure may undergo some further changes.

Figure 32: A *Techno-Economic Network* Depicting the Introduction of the *Single Buyer Procedure* in France



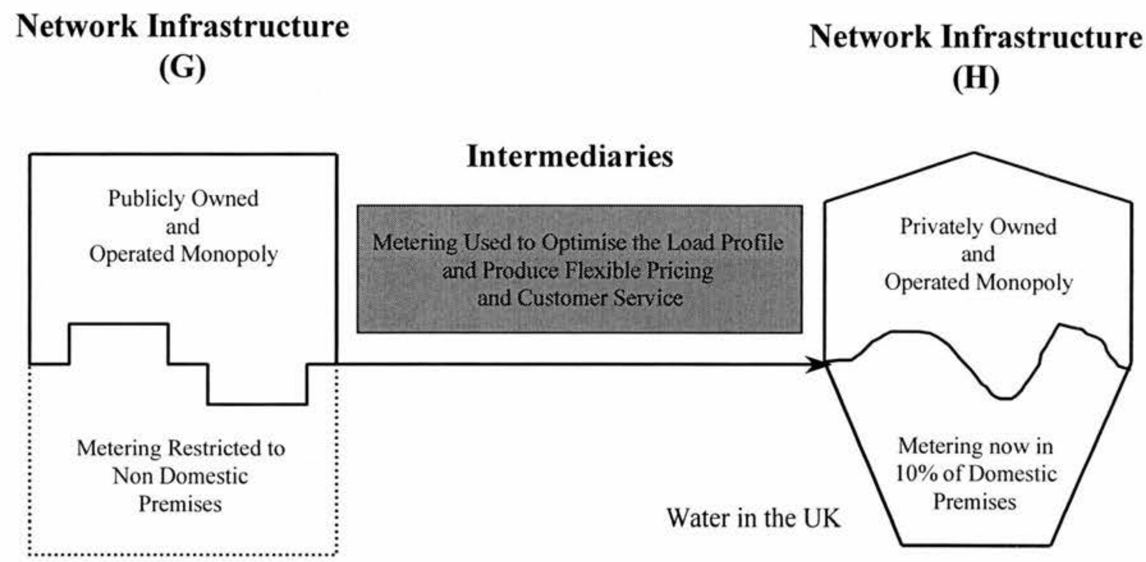
The *Single Buyer Procedure* has also implications in technological development. Since the *Single Buyer Procedure* is in some respects an attempt by the French Government to protect its electricity generation interests, greater emphasis is being placed on making these generation assets more efficient. Over the years EdF has been developing ever more sophisticated 'time-of-use' tariffs by means of mains-borne ripple control. In addition, two-way switching and 'real-time' pricing is gradually being introduced. This has meant that metering is being used to optimise the load profile and develop more flexible customer service. In figure 32 this is depicted by a change of shape of the metering part of the *Techno-Economic Network*.

Figure 33: A *Techno-Economic Network* Depicting the Maintenance of the Delegated Management Model with Respect to Water in France



In the French water industry, the principle of delegated management has operated and has continued to operate over the last twenty years with little change. This is partly testament to the success and durability of this type of regulatory system, but it is also evidence that the development of information technology and metering (unlike the electricity and gas industries) has little effect on the regulatory process. In figure 33 this is depicted by the shape of the *Techno-Economic Network* remaining the same over the twenty years of study. Also, the AdBs and the Ministry of the Environment mean that within the regulatory process there are active trade-offs between local political forces, private sector economic forces, regional environmental forces and national strategic forces. It is a form of regulation that has proved successful for many years and it is significant that this form of administration has not come under any pressure from the régime where private companies are regulated which has developed in the UK.

Figure 34: A *Techno-Economic Network* Depicting the Transformation of Public Monopolies into Private Monopolies in the UK with Aspect to Water



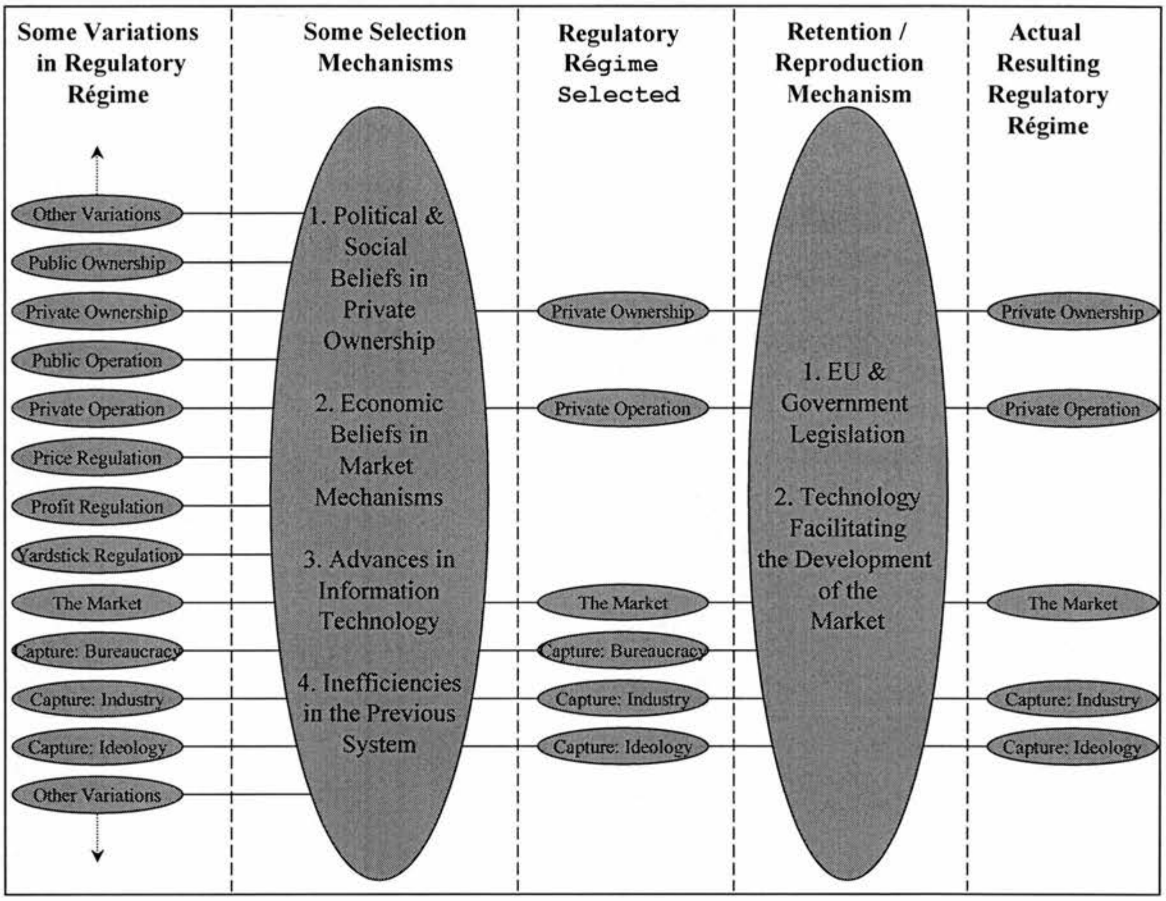
Political intermediaries rather than any technical considerations have dominated the regulation of water in the UK (this is depicted in figure 34). The major *intermediary* has been desire to separate the investment required for refurbishment of the water industry from the exchequer. Nonetheless metering has played an important role in the transformation of a publicly owned and operated monopoly structure (G) to a privately owned monopoly structure (H). The introduction of metering is allowing the introduction of more flexible pricing and customer services. There has been a massive refurbishment and development of the water supply and sewerage infrastructure since privatisation in 1989. This have been needed to maintain the UK's decaying water supply network which has suffered considerable under-investment when it was held in public hands and to meet EU standards. These improvements have caused price increases greater than inflation since privatisation, but should not be attributed to any fundamental flaw in the regulatory system.

Just as with the analysis of the development of metering technology in Chapter 15 using *Sociotechnical Constituencies* a number of similar problems occur with *Techno-Economic Networks*. The first is the bounding problem in defining each of the actors or intermediaries. The concept of a system is that one actor or intermediary is distinct from another and its relative importance on the network as a whole has a value judgement. This value judgement has been generated from empirical case study analysis derived from archival texts and interview transcripts prescribed in *Actor-Network* methodology. As described in section 5.3.3 it is not sufficient to return to texts whether it is published articles or interview transcriptions to obtain a theory repeatable by experiment. Neither can tacit components to individuals competencies nor their beliefs be unravelled using this form of *Actor-Network Theory*. Also by definition this is the analysis of a snapshot at a specific time and although useful in defining the drivers in the system, is of little help in tracing the development of a regulatory environment.

16.3.3 An Evolutionary Explanation for Regulatory Development

Another way of approaching the principles of regulatory change is studying it by means *Evolutionary Theory* as described in sections 5.3.4 and 15.3.3. In the case of regulation, the variation needed for an evolutionary framework can be found in the different forms of regulatory régimes described in sections 4.4 and 16.2. The selectors meanwhile are such factors as the state of technological knowledge, political belief systems and natural physical constraints. A mechanism of retention and reproduction can be found in codified rules such as legal statues, for instance Acts of Parliament, patents, etc.

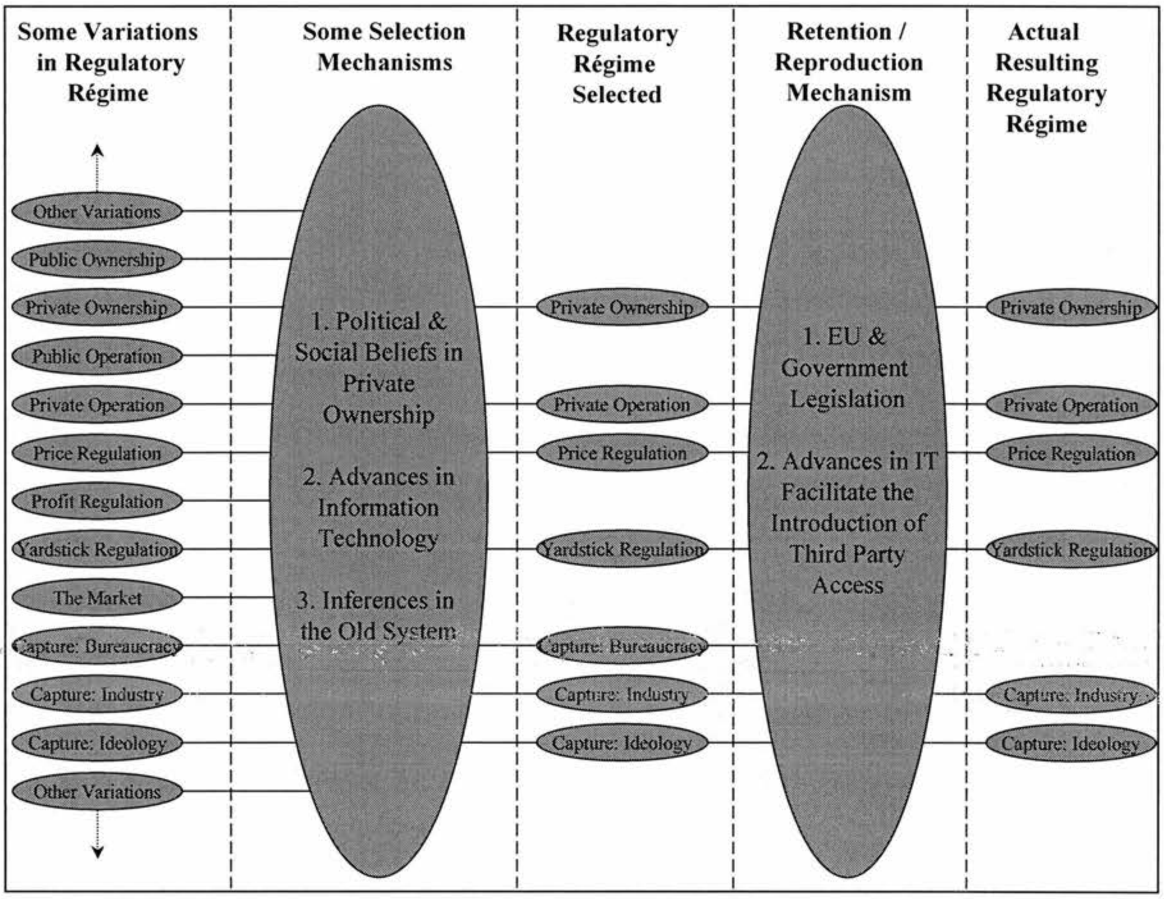
Figure 35: An Evolutionary Analysis Depicting Deregulation in the UK



For a deregulatory framework to evolve, the variations (first column in figure 35) in the regulatory systems, which are represented by the regulatory frameworks presented in section 4.4, must undergo a selection process. The selection mechanisms in the case of the deregulation mode are similar to the intermediaries in *Techno-Economic Networks*. For example, the belief that market and entrepreneurial skills are more desirable than bureaucratic Government control, has been a major factor in the selection process. Also the advances in information technology have facilitated the implementation of deregulation in the gas and electricity supply industries in the UK. The retention of this system are by means of Acts of Parliament such as the Gas Act (1986) and the Electricity Act of 1989 as well as technological artefacts, such as metering, which are defined in codes of practices.

There has also been a growing body of consensus of the inability of Government to acquire the knowledge necessary to improve upon the market. This contrasted with the paternalist view that dominated the nationalised utilities, where the hope was that a group of right-thinking and disinterested people would run undertakings in the public interest, of which they were supposed to be the arbiters. Rather it is argued market forces should play a much greater role. This is evidence of an evolving process relying on both social and non-social events which is suitable for an evolutionary framework. Nonetheless figure 35 indicates that this form of regulation has been somewhat 'captured' by groups who believe in this ideology.

Figure 36: An Evolutionary Analysis Depicting the Introduction of *Third Party Access* in the UK



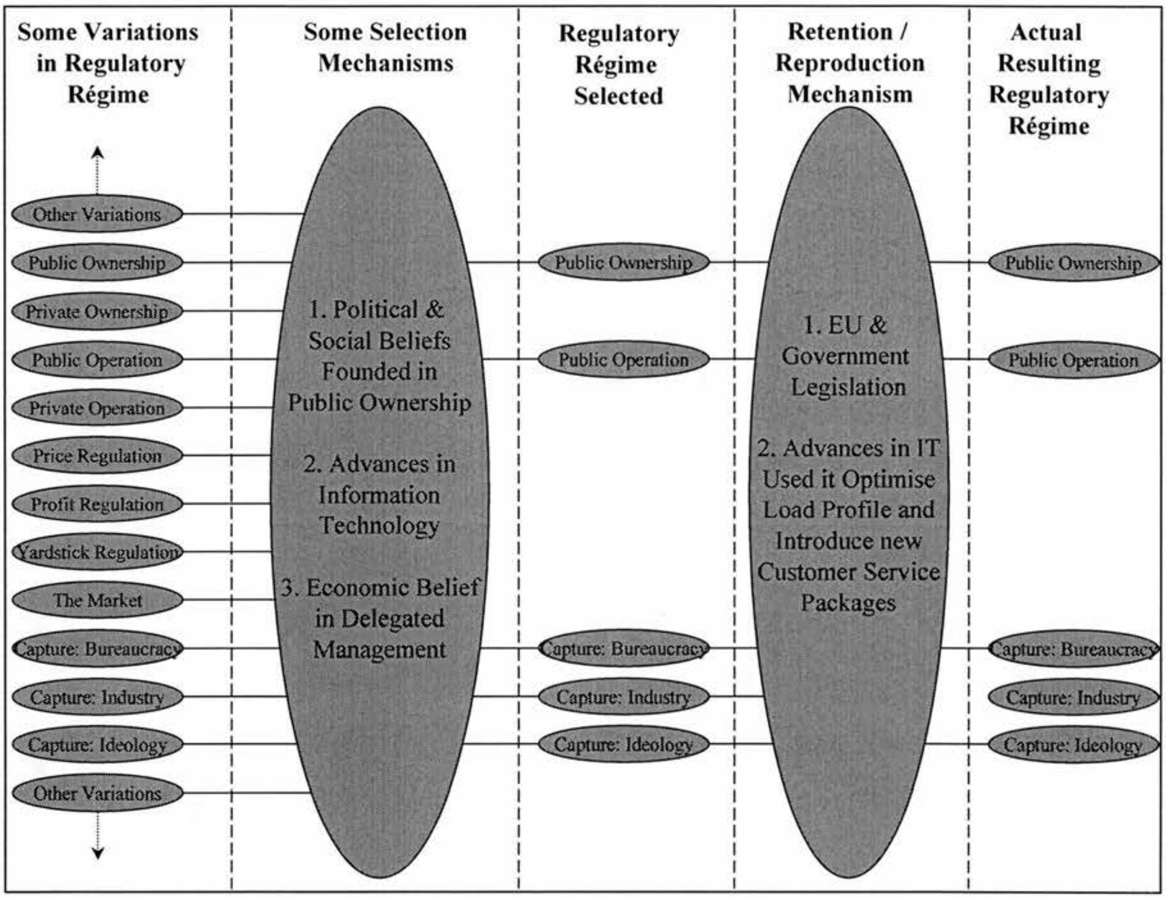
An evolutionary approach to the development of *Third Party Access* in the UK (depicted in figure 36) is very similar to that of the model for deregulation. The only difference is the 'natural monopoly' nature of the gas and electricity transportation infrastructures in the UK. Therefore instead for deregulation there is a form of 'yardstick' regulation based on price control (RPI-X). Again this is retained in the various acts of parliament. It is also worth emphasising that the UK system of deregulation has been reproduced in a number of other countries (but not in France) although with significant variations. This is evidence that once these regulations are imposed they can be reproduced in slightly different forms, depending on the countries' physical and cultural needs.

The major area of criticism comes from three areas; the privatisation process, the ownership of the private companies and the capture of the regulatory process by an economic orientated regulator. In many other European countries, for example Norway, Sweden and Finland deregulation of their network infrastructures have been accomplished without privatising their assets. Indeed deregulation accompanied by privatisation is a peculiarly British phenomenon. It is one cynical interpretation that the UK Government wished to privatise their utility infrastructures not for any sound economic reasons but in order to release capital for the Government of the day. Even if this is not strictly true it has exposed this UK form of regulation to serious criticism. The first is that the assets were sold off at knock-down values, and the initial price controls were too slack over the first few years after privatisation. As a result, the UK utilities made excess profits and incumbent senior management (coined 'fat cats' by the UK press) walked off with windfall share option schemes. To be fair to the Government, it is a difficult process to value the assets of a utility and since this was the first time privatisations on such a scale had taken place, it still remains a considerable achievement.

One of the other issues that was pioneered in the UK was the regulatory mechanism that was based on caps on price, rather than a cap on rate of return. Rate of return regulation had been used in the USA for many years, but many UK economists recognised this as a suboptimal mechanism. Rate of return regulation allows a utility to set its tariffs on a 'cost plus' basis. This causes an inefficiency in that a utility can claw back all its expenditure through the regulatory processes. Similarly any efficiency gain and increased profits, made through innovation, has to be handed back. Thus, proponents of price regulation claim that this discourages the incentive to innovate. On the other hand, regulating companies on price alone encourages the regulated firm to cut costs. Inevitably one of the first costs to be cut will be research and development. In essence this is a microcosm of the market pull versus technology push dilemma. Just as neither market pull nor technology push fully describe the innovative process, neither price nor profit regulation alone are sufficient to administer the regulatory process. This has now been generally recognised, and although the UK form of regulation is still founded on price, there are incentives in the regulatory formulae to invest in factors other than financial gain. For example every gas and electricity customer in the UK pays a one pound annual levy towards energy efficiency which is known as the Non Fossil Fuel Levy. This as well as the free installation of meters in the water industry, are instances where technology is being given a pull in the market environment of price control regulation. In addition as a direct result of *Third Party Access* and the change from coal to gas-fired generation, the UK has met its CO_2, SO_2, and NOx environmental emission limits. At the same time the UK deep mined coal industry has almost been destroyed, contributing to immense sociological change in the UK. This is an example of the 'tar baby effect' described in section 3.2.

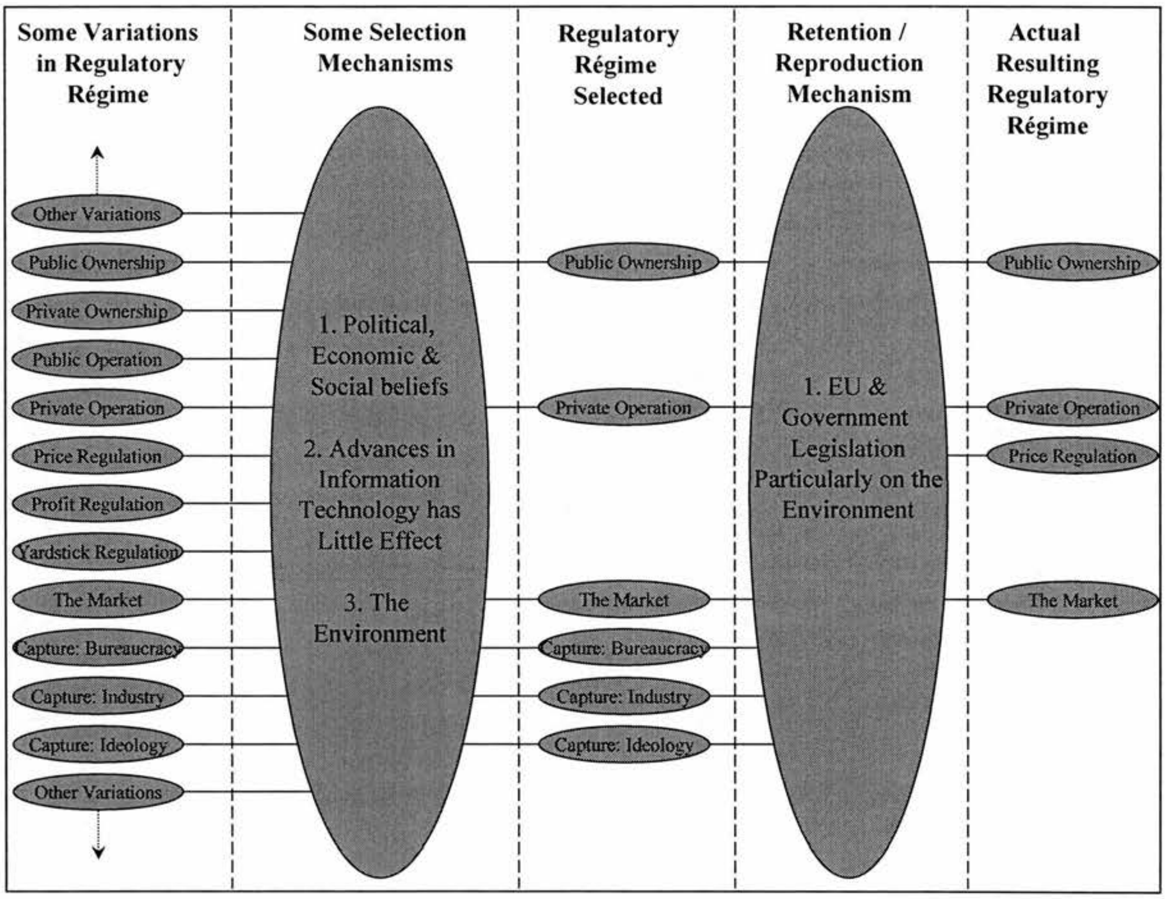
The *Single Buyer Procedure* (see figure 37) illustrates how a public utility can develop in a different way, depending on the selection regime in the country. France is unevenly endowed with natural resources. Though rich in agricultural products, it is poor in raw materials such as oil, coal and gas. Also due to France's large nuclear commitment (see chapters 7 and 9 as well as figure 32) the *Third Party Access* model jeopardises the countries economic and strategic health. This has resulted in legislation maintaining EdF's and GdF's monopolies. The French Government's implementation of the *Single Buyer Procedure* has meant that metering technology has been used to maximise the output of the existing vertically integrated network.

Figure 37: An Evolutionary Analysis Depicting the Introduction of the *Single Buyer Procedure* in France



The *Single Buyer Procedure* (figure 37) on the other hand, allows France to continue is commitment to social mechanisms in the market and the maintenance of trade unions' influence in utility management. However the greatest concern is the role that EdF and GdF play within the regulation process. It has been described as a 'State within a State'. In other words the regulatory process has been 'captured' by EdF and GdF and in a bureaucratic and ideologically fossilised framework. Thus EdF has been described as 'Kafkaesque' and 'inhuman' a label which will have to be shaken off, if their privilege status is maintained. Thus, It will be increasingly difficult for the French Government to maintain EdF's and GdF's monopolies if *Third Party Access* continues to be a success.

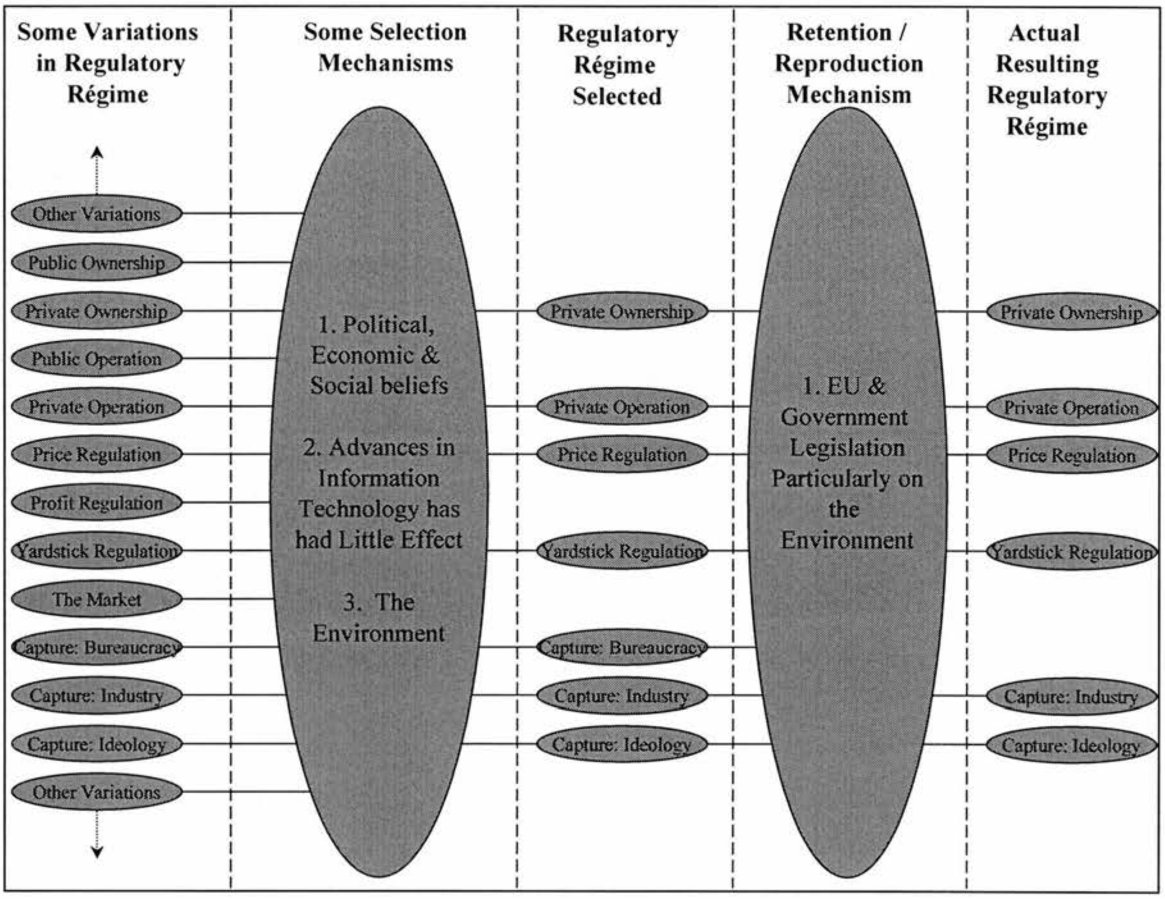
Figure 38: An Evolutionary Analysis Depicting the Maintenance of the Delegated Management Model in France



The water industry in France is evidence of a relatively stable regulatory system that has evolved little in the past twenty years (see figure 38). Little in the selection environment, either on the political, social, economic or technical scene, has affected its administration. The only area of development is in the sphere of the environment, which has not caused a major restructure. This increase in interest in the area of the environmental regulation in France is signified by the legislation in 1992.

The stability of this regulatory framework is testimony to the 'delegated management' form of regulation. In contrast to the other form of regulation discussed, there is no discernible 'regulatory capture'. Nonetheless the Government still plays a significant role, and the lack of agreement on metering and communications standards (see section 13.4) is inhibiting technological development.

Figure 39: An Evolutionary Analysis Depicting the Transformation of Public Monopolies into Private Monopolies in the UK.



Unlike the system in France the UK system of water regulation has evolved considerably over the past twenty years (depicted in figure 39). This has been caused by political selectors in that the system of liberalisation that has occurred in other utilities and has also been applied to water. However with respect to water, the result is somewhat different in that there is neither competition in production and supply nor *Third Party Access*. On the technological side, metering technology is helping to develop a more cost reflective system.

The same criticisms to that of the electricity and gas transportation businesses apply to this form of regulation in water (see figure 36). It is therefore susceptible to capture, by industry, the 'fat cats' and regulatory ideologies. There is however one other problem with the direct privatisation of public to private monopolies, and that is democratic accountability. When the public owns a utility, it is nominally responsible to the democratically elected Government of the day. Moreover, in a competitive market, if customers are dissatisfied, they can move to another company for their custom. In a private monopoly, there is neither of these regulatory balancing mechanisms. Power is placed in an independent regulator (albeit appointed by the Government). But the question is who regulates the regulator?

16.4 REGULATION POLICY

Techno-Economic Networks and *Evolutionary Theory* can now be used to illuminate policy decisions in regulation. The most significant is that the primary duty of regulation should be the protection of the interests of customers by statutory guidance on social, environmental and technical matters, as well as economic issues. The role of technology is crucial. The unbundling of production transportation and supply functions should be considered only if it is technologically feasible, namely in electricity and gas supply as well as electricity generation. Although price regulation (RPI-X) is useful in preventing monopoly excesses, it is unclear whether privatisation is necessary. Regulation should to be devolved to local level as much as possible. This varies from subsidiarity clauses in European legislation to local democratic input. Thus in France with its large nuclear commitment it would clearly be very disruptive, even catastrophic, for the European Union to impose *Third Party Access*. On the other hand the *Single Buyer Procedure* should not allow France to benefit disproportionately from its controversial nuclear programme. Thus regulation is also a temporally dependent phenomenon, meaning that a régime of regulation that is suitable in one era may not be suitable in another era. This dimension should also have a democratic component in which all stakeholders should have a say, whether it be through public ownership or delegated management as in the French water industry or strong consumers' committees to regulate the nominated private *Agent*.

The size of the nominated *Agent* is another important factor. It should be large enough to take advantages of economies of scale as the RECs in England and Wales, but should not be so large as to wield monopoly power. Where natural monopolies do exist, as in the water industry and power distribution some form of synthetic competition should be sought. Two forms have been analysed during the course of this thesis. 'Yardstick' competition combined with price regulation is popularly used in the UK utilities, while franchised out delegated management has proved successful in the French water industry. The 'delegated management' mechanism has a number of advantages. The tendering system introduces competitive pressures, the private operation installs a rigorous market discipline and public municipal ownership provides a democratic accountability. The fact that this mechanism has stood the test of time and remains relatively unchallenged is testament to its success. A 'yardstick' form of regulation has also operated for many years, particularly in the USA, and has come under more critical scrutiny. Concerns have been expressed on the method of regulation, particularly whether it should be price or profit regulation or a mixture of both. In the UK the major form of regulation continues to be the regulation of prices, but windfall profits caused by the manipulation of the regulatory mechanism need to be addressed. Other concerns have been expressed about the effectiveness of the 'yardstick' mechanism. This type of performance monitoring, or benchmarking, is used in the regulation of the RECs and Water Service Companies in the UK where their standards of performance are published in league tables. The theory is that the company at the foot of the table should have an incentive to improve its performance. In the case of the England and Wales Pool, comparison with other electricity trading systems or even the trading of other commodities such as oil and gas may be fruitful in assessing its efficiency. One note of caution for 'yardstick' monitoring is that it is often difficult to measure. For example due to sociological, or for geographical reasons, comparisons between different monopoly areas may be difficult. This issue in benchmarking is known as trying to 'compare apples with oranges'. The 'comparing apples with oranges' issue becomes even more apparent when inter industry comparisons are made, between for example, the electricity and gas industry. But above all, probably one of the most controversial areas in 'yardstick' regulation is 'who regulates the regulator?'.

With 'franchised out', or 'delegated management' type of regulatory system where the *Principal* is publicly owned, the regulation of the *Principal* is a relatively straight forward process. It should be democratically accountable and should have some degree of local or municipal representation. When the form of regulation is publicly owned and operated or privately owned and regulated, the role of the *Principal* becomes a little more problematic. The publicly owned and operated method will be discussed first. This form of regulation shares features of self regulation in that the *Principal* and the *Agent* are one and the same. When the industry is publicly owned and operated, in theory the companies should be regulated by democratic accountability. As it has been explained in Chapter 3 and shown in the examples of the nationalised industries described in the case studies, this method of regulation is open to both bureaucratic torpor and capture by bodies such as trade unions, and wider Government goals such as national security. It is for these reasons that when the *Principal* is a large national Government entity it is now viewed to be undesirable. This is not to say that Government representation is not crucial but that there should be wide representation at local as well as national level. It is also important that the *Principal* should express the widest range of interests. One of the major themes of this thesis is founded on is the notion that regulation is a multi-faceted process and has particularly tried to explore the role that technology has played in this process. The greatest danger to regulation is when the process is captured by one particular interest group. One of the ways to ensure that this does not take place is by democratic accountability of the regulators. In saying this, each of the interest groups and each industry should be fairly represented. Recent proposals by the UK Government go some way to address these issues, stating that utility regulators should have clear social and environmental obligations as well as economic ones. There has also been recommendations to combine of Offer and Ofgas which is also a step forward in gaining more industry-wide co-operation. This goes at least some of the way to addressing the issue of 'who regulates the regulator?' but does not fully acknowledge the role that technological innovation has played in the regulatory process.

Figure 40: Proposed Regulatory Structure

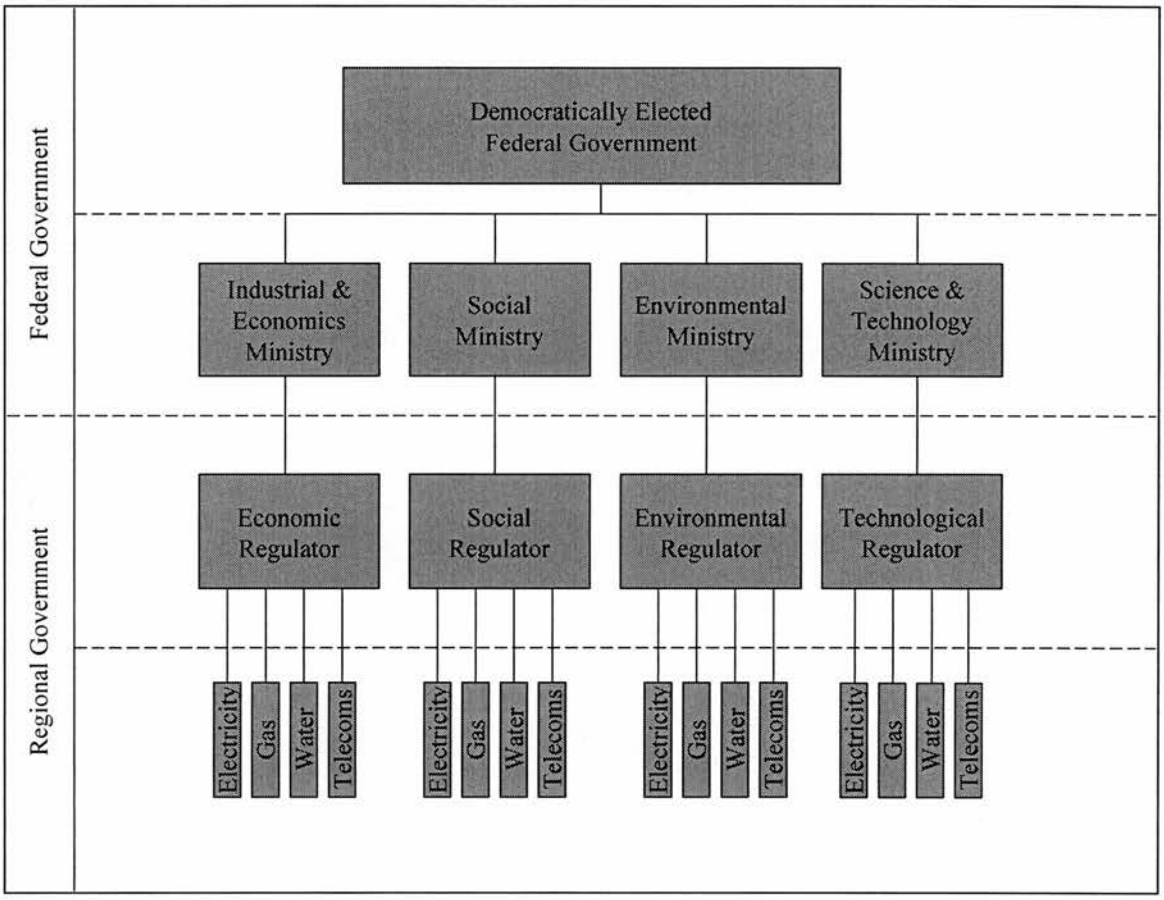


Figure 40 shows a proposed structure for regulatory and technology policy in public utilities. In effect, it is suggested that each country or district and each industry, should have a bespoke regulatory policy which feeds into separate regulators (or *Principals*) covering economic, social, technological and environmental policy. The notion of *Constructive Technology Assessment* could play a role here where separate specialist regulators then feed into executive Government level. Thus sociotechnical change is overtly coupled with Governance and regulators are seen more as facilitators advising on, rather than prescribing, policy. As far as the *Agent* is concerned, it is argued that the case of private over public sector ownership is still unproven. It is however considered that some market discipline is necessary, either by delegated management or full privatisation, to ensure that the *Agent* does not 'capture' policy.

16.5 CONCLUSION

The uses of the principles of *Techno-Economic Networks* and *Evolutionary Theory* described in this chapter have proved to be useful analytical devices. They talk of regulation as a multi-functional process and provide a framework for comparative analysis between regulatory régimes. They also provide differing perspectives to the analysis. *Techno-Economic Networks* are bounded by their actors, and describe regulation as an overtly social phenomenon. In other words the actors have been brought together in conscious and deliberate process to describe the dynamics of regulatory change. Evolution on the other hand, sees the social process as just one of many selectors in a random conscious and unconscious process which also include physical constraints such as rainfall, oil and gas reserves and so on. It is therefore concluded that both evolutionary frameworks and *Techno-Economic Networks* are useful as explanatory tools for different aspects of regulatory change. The evolutionary approach adopted in this study also was able to highlight the 'capture' mechanism in regulatory process. This was shown to be a significant factor in all the forms of regulation with the exception of the 'delegated management' model.

Also the analytical mechanisms provide recommendations for regulatory policy. It is recommended that independent regulators should be set up not primarily on industry lines like Offer, Ofgas, Oftel and Ofwat but on economic, sociological, environmental and technical disciplinary lines, in the format described in figure 40. There is a precedent in this in the water industries in France and the UK, both of which have separate regulators for economics and the environment. Within these bodies there would be a function that addresses individual industrial needs. There also needs to be considerable democratic representation at local, regional, national and international level. But it is important that these regulatory bodies should be run by independent experts in their own disciplinary field. These should then feed into ministries at Government level where local people are well represented. In this way, regulation can be seen to be run for the people and accountable to the people.

CHAPTER 17

CONCLUSIONS

17.1 INTRODUCTION

This thesis has studied the interrelation of technology and regulation in public utilities. In order to do this it was argued that the construction of 'theory' was the simplest and clearest way of creating a framework for the analysis. It was also found that different 'theories' with different (and starkly contrasting) philosophical foundations provided different insights into to innovation and regulatory process. The solution adopted in this research is a pragmatic one. No one theoretical framework presented in the literature review adequately described the phenomena explored in this study. Neither was a new theoretical framework developed during the course of the research nor was there an attempt to unify the competing approaches. Rather it was found that each of the frameworks was useful at describing certain aspects of the process of innovation and regulation. This in turn was used to appraise the validity of each of the theoretical approaches and to provide a richness to the analysis. Each theory also provided a common frame of reference in which analysts are able to discuss technological innovation and regulatory development. Moreover the analysis was not only used in a descriptive form but also as a prescriptive tool which could be used to guide policy making. In this way policy recommendations were made with respect to technology and regulatory development.

In order to define the parameters of the research within manageable proportions the thesis considered the case of the development of metering and communications technology in public utilities in France and the United Kingdom over the past twenty years. To obtain as much validity as possible, a multiple case study methodology was adopted using an 'emergent grounded' approach. In effect, this meant the research was conducted within the bounds of the theoretical frameworks presented in Part I. Nonetheless, the case studies explored in Part II were conducted without any reference to one particular framework, in an attempt to see if either a theory would 'emerge', or whether one theoretical approach was more suitable than another for explaining the phenomena explored. This is not to say that the case study descriptions were not impartial, and indeed this is entirely consistent on the holistic research design that included participative as well as an analytical components. Part III then evaluated the technological and regulatory frameworks presented in Part I in order to develop a descriptive analysis and explanations for the events explored in the case studies (Part II).

17.2 FINDINGS

Chapter 14 evaluated the *Techno-Economic Paradigm* as an explanation for the changes occurring in public utilities. It was concluded that within the telecommunications industry the *Techno-Economic Paradigm* was indeed a useful concept. Yet it became less convincing if the concept was applied to other industrial sectors. For example, in the telecommunications industry the advance in information technology has played a significant role in regulatory change, while in the electricity and gas industries information technology only acts as a more minor facilitator for change. Moreover, information technology has had very little effect to date on the regulatory development in the water industry. In order to describe the specific nature of technological change the development of metering technology was considered. So in chapter 15 the focus of analysis was directed to a more *meso* scale in the evaluation of the development of metering and communications.

Systems Theory was used as a starting point in chapter 15. It was able to describe metering as part of a larger infrastructure and highlighted that the technology could not be understood unless it was seen as part of the system as a whole. Also it was found that with the advent of microelectronics and advanced communications, mechanisms in the energy and water utilities is changing the meter's role from a metrological device to a customer service interface. Moreover the repercussions of this change, although yet to be fully realised, were more marked in electricity than they were in gas and water. It followed that if the metering technology was changing, the system as a whole must be changing as well. It was also found that although *Systems Theory* as described by Hughes (1982) was useful at developing a framework for system development, it had less to say on change occurring in a mature network infrastructure. It was found that the 'highway' model proposed by Saehney (1992) was suitable for describing changes in the telecommunications networks but had little relevance to energy and water utilities which contained an additional production component to the network infrastructure. Therefore, *Sociotechnical Constituents* and *Evolutionary Theory* were argued to be further useful concepts in describing and explaining the development of metering in the electricity, gas and water industries.

Here there were notable differences in metering development, not only between utilities but also between France and the UK. By studying the process through a modified form of Molina's (1996) 'diamond of alignment', *Sociotechnical Constituencies* showed that the developing technology was a result of a socio-cultural milieu. In France for instance, the electricity and gas industries were dominated by the need to supply a secure and independent source of energy, and metering was developing to maximise the load factor. In the UK meanwhile, metering was developing to allow the introduction of competition in the energy supply sector. In water on the other hand metering was beginning to be installed in the UK (specifically England and Wales) due to changing pricing régimes and environmental factors. While *Sociotechnical Constituents* were used as an analytical tool to describe metering development, *Evolutionary Theory* was found useful in explaining metering development. In this mode of thought, selectors both human and non human were responsible for 'choosing' certain forms of metering technology best suited to the regulatory environment. The specification for these technologies was then retained in legal statutes ranging from patents, codes of practice and inter-Governmental standards. Meter and software manufacturers then reproduced the technology so that the selection process could start all over again. So while *Sociotechnical Constituencies* provided a description for metering development, evolution provided a possible mechanism for metering development. In this way a more rounded picture of the development process was achieved.

Chapter 16 then turned its attention to the development of the system of regulation over the past twenty years in France and the UK. Again *Systems Theory* was used as the starting point and it was concluded that *Techno-Economic Networks* were the more suitable frameworks to describe regulatory development, than the more techno-centric approach *Sociotechnical Constituents*. Thus *Techno-Economic Networks* were used in describing the change in the regulatory process in a more socio-centric way. *Techno-Economic Networks* described how metering technology had been used as one of many actors and intermediaries to maintain the vertically integrated structure of the gas and electricity industries in France. At the same time metering technology was facilitating the deregulation process and the privatisation of public sector assets in the UK. Again while *Techno-Economic Networks* described the process, *Evolutionary Theory* was explored as a mechanism for change. In this case, the variables were considered to be the various modes of regulation described in the literature review. The selection mechanisms included such factors as political beliefs, the state of technological development (including metering) and social equality. These asymmetries in the regulatory environment can then be balanced by mechanisms such as *Constructive Technology Assessment*. These rules are then retained in Acts of Parliament, which then provided a basis for future developments in regulatory policy.

17.3 IMPLICATIONS FOR METERING AND TECHNOLOGY POLICY

These findings, the clearest of which is that there is neither a correct policy nor a correct blueprint for technology and regulatory policy, have significant implications for policy makers. Policy is dependent on both spatial and temporal factors. A policy that is right for the electricity industry in the UK may not be right for the water industry in the UK or the electricity industry in France. This can be illustrated by the fact that during the nineteen-fifties and nineteen-sixties both the UK and France followed a similar policy of publicly owned and operated utility networks which created the interconnected gas and electricity networks of today. Today however, now that the infrastructure is complete, new pressures such as innovations in information technology, are causing changes in the structure. These structures may also vary from country to country, not only for socio-cultural reasons but also because of geographical constraints. The fact that France is poorly endowed with indigenous sources of energy means that it has adopted different technological and regulatory policies from the UK. Similarly France is over twice the size of the UK with roughly the same population size. This low population density has implications for the operations, not only of water but also energy supply.

Sections 15.4 and 16.4 proposed some policy measures to take account of the variations in time and space. The major thrust of these is that the advisory process should not be vested in one party but spread amongst many interested parties varying among academic, industrial and consumer groups. Another important feature of this structure is that final executive power should not reside in regulatory authorities. It is crucial that their role should be advisory rather than executory. Rather executive power should, as far as possible, lie with the democratically elected Government at district or national level. This allows the regulatory process to be tailored to balance such factors geo-cultural circumstances and technological development. It is also important that regulation should not be seen as a static process and will evolve over time with along with the development of knowledge and process of democratic change.

17.4 FURTHER RESEARCH

The theoretical frameworks described in this thesis provide a structure for an applied methodology which could prove useful in deciding different aspects of regulatory and technology policy. *Sociotechnical Constituents* and *Techno-Economic Networks* are useful methods of describing the status of a particular technology or regulatory environment. The results of such analysis can then be applied in an evolutionary framework to appraise the future of an individual technology or regulatory régime over time. This could be of use to both companies who wish to invest in public industry infrastructure, and Governments who wish to overhaul their utility management, to adapt to evolving technological and social needs. In order to evaluate this methodology, further trials with public sector and private sector clients will be required.

Further work is also suggested on the theoretical foundations of the application of *Evolutionary Theory* to the social sciences. Attention needs to be paid to the variation, selection and retention/reproduction mechanism of *Evolutionary Theory*. This thesis has restricted itself to larger-scale (*macro* and *meso*) social, economic and technical evolution. To draw an analogy with the biological sciences, this study is viewing the evolutionary process at the phenotypic and environmental level rather than the molecular level. To unravel the *micro* processes in technological and regulatory evolution may prove difficult. The key will be to describe a codified replication mechanism like DNA in biological evolution. It was suggested sections 15.3.3 and 16.3.3 that codified rules such as patents and legal statutes might play a role. This may also be extended to tacit rules such as social taboos. Also during the course of the thesis it has been argued that metering cannot be understood unless it is seen as a component of a larger infrastructure system. Thus understanding of the relationship between the artefact and its surrounding environment will also be a key to unravelling the dynamics involved in an evolutionary approach.

The final area of future research is in the development of regulatory studies and technology studies, as academic disciplines in their own right. A major theme of this thesis is the interdisciplinary nature of technology and regulation. It is also concluded that the most valuable work on technology and regulation occurs within the disciplines of economics, sociology and political science. A missing ingredient is often the fact that the study of technology is not cross-disciplinary. Therefore further work is required of a collaborative nature between academics from varying backgrounds. The aim of this work would be to compare and contrast approaches in a spirit of co-operation, respect and mutual fulfilment.

THE END

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ABBREVIATIONS

ABB Kent: ABB Kent Meters Ltd

AdB: L'Agencies de Bassins

AGB: Audit of Great Britain

AGR: Advance Gas-Cooled Reactor

AMPY: An Electronic Meter Manufacturer

AMR: Automatic Meter Reading

ATG: l'Association Technique de l'Industrie du Gaz en France

BG: British Gas plc

BGC: British Gas Corporation

bps: Bits Per Second

BS: British Standard

BSI: British Standards Institute

BT: British Telecom

CALMS: A No-Ring-Trunk Dialling Technology

CATV: Cable TV

CCGT: Combined Cycle Gas Turbine

CD Gaz: An Ancillary Gas Company

CEA: Central Electricity Authority

CEA Commissariat à l ' Energy

CEGB: Central Electricity Generating Board

CEN: European Electronic Metering Standardisation Committee for Fluid Flow Meters (Gas & Water)

CENELEC: European Electronic Metering Standardisation Committee for Electricity Metering

CETIAT: Technical Centre for Ventilation and Heating (France)

CfD: Contract for Difference

CFM: Compagnie Française du Méthane

CGE: Compagnie Générale des Eaux

CGT: Fédération de l'Éclairage

CMSG: Ofgas' Competitive Metering Steering Group

CNRS National Centre for Scientific Research

CNET Centre for the Study of Telecommunications

COFRAC: French Accreditation Committee

CORGI: Council of Registered Gas Installers

CSI: Le Centre de Sociologie de l'Innovation de l'École Nationale Supérieure des Mines de Paris

DA/DSM: Distribution Automation/Demand Side Management

DDR: Diagnostic Data Reader

DGES: The Director General of Electricity Supply (UK)

DGGS: The Director General of Gas Supply (UK)

DIREN: Ministry of The Environment (France)

DLMS: Distribution Line Messaging System

DoE: Department of the Environment (UK)

DRIRE: Ministry of Industry (France)

DTI: Department of Trade and Industry (UK)

DWI: The Drinking Water Inspectorate (UK)

EA: The Environment Agency (UK)

EC: European Commission

EdF: Electricité de France

EDI: Electronic Data Interchange

EDDI: E6 Diagnostic Data Interface

EGF: Electricité-Gaz de France

EJP: Peak Day Demand-Reduction Option

ESIS: The Electricity Settlement System (UK)

EPOR: Empirical Programme of Relativism

EPOS: Electronic Point of Sale

ESRC: Economic and Social Research Council (UK)

EU: European Union

FFL: Fossil Fuel Levy

FNDAE: Fonds National Pour le Development des Adductions d'Eau

FT: France Télécom

FT-SE: Financial Times Share Index

GCC: The Gas Consumers' Council (UK)

GEC: General Electric Company

GdF: Gaz de France

GPO: General Post Office (UK)

GPT: A Telecommunications Manufacturer

GSP: Grid Supply Point

GW: Gigawatts

HEBS: Home and Building Electronic Systems

HMIP: Her Majesty's Inspectorate of Pollution (UK)

ICC: Communicating Customer Interface

IEC: International Electrotechnical Commission

IGE: Institution of Gas Engineers (UK)

IPA: Ian Pope Associates

ISO: International Standards Organisation

IT: Information Technology

kV: Kilovolts

kW: Kilowatts

LCD: Liquid Crystal Display

LDZ: Local Distribution Zones

LNG: Liquefied Natural Gas

LPG: Liquefied Petroleum Gases (Usually Butane or Propane)

LRMC: Long-Run Marginal Cost

LV: Low Voltage

MHz: Megahertz

MMC: Monopolies and Mergers Commission (UK)

MMS: Manufacturing Message Specification

MW: Megawatts

mW: Milliwatts

NGC: The National Grid Company

NOSHEB: The North of Scotland Hydro-Electric Board

NP: National Power

NRA: National Rivers Authority (UK)

NTS: National Transmission System

Ofgas: Office of Gas Supply (UK)

Offer: The Office of Electricity Regulation (UK)

OFT: Office of Fair Trading (UK)

Oftel: Office of Telecommunications Licensing (UK)

Ofwat: Office of Water Services (UK)

OTV: Omnium de Traitements et de Valorisation

PC: Personal Computer

PES: Public Electricity Supplier

PG: PowerGen

PLAN: Power Line Automation Network

PLC: Power Line Carrier

PPM: Prepayment Meters

PSTN: Publicly Switched Telephone Network

PWR: Pressured Water Reactor

RAP: Régie Autonome des Pétroles

RATP: Parisian Transport Company

REC: Regional Electricity Company

RTP: 'Real-Time' Pricing

SATESE: Services d'Assistance Technique à l'Explotation des Stations d'Épuration

SCEMA: Smart Card Electricity Metering Association

SCOT: Social Construction of Technology

SFR: Société Française de Radiotéléphone

SLE: Suez Lyonnaise des Eaux

SNCF: Société Nationale de Chemin de Fer (French National Railways)

SNGSO: Société Nationale des Gaz du Sud-Ouest

SNPA: Société Nationale des Pétroles d'Aquitaine (later called Elf Aquitaine)

SPC: Stored Programmed Control

SPDE: Syndicate Professional des Distributeurs d'Eau

SPEGNN: Syndicat Professionel des Enterprises non Nationalisées

SRAE: Services Régionaux d'Aménagement des Eaux

SRMC: Short-Run Marginal Cost

SSA: Pool Settlement System Administrator

SSEB: The South of Scotland Electricity Board

SYS: Seven Year Statement

TC: Technical Committee

TICGN: Taxe Intérieure à la Consommation du Gaz Naturel

TOU: 'Time of Use'

UKAMRA: The United Kingdom Automatic Meter Reading Association

UKDCS: United Kingdom Data Collection Services

UTPC: Universal Tariff Processing Concept

UWWTD: EU Directive Covering Urban Wastewater Treatment

V: Volts

W: Watts

WCC: Water Consumers' Council

WSC: Water Service Company

X-25: A Telecommunications Protocol